

The Diagnostic Value of Large Bowel Radiography in Contemporary Medicine



FRANS-THOMAS FORK

Lund 1982

MALMÖ 1982



Digitized by the Internet Archive
in 2026

https://archive.org/details/IA41553210_0013

From the Department of Diagnostic Radiology
(Head: Professor Tord Olin), University of Lund,
Malmö General Hospital, S-214 01 Malmö, Sweden

THE DIAGNOSTIC VALUE OF LARGE BOWEL RADIOGRAPHY
IN CONTEMPORARY MEDICINE

FRANS-THOMAS FORK

MALMÖ 1982



To my family,
 Helena and Ronald,
 and to my parents

INITIUM SAPIENTIAE TIMOR DOMINI
 LAUDATIO EIUS MANET IN SAECULUM SAECULI

ACKNOWLEDGEMENTS

I am especially grateful to Professor Erik Boijesen, the initiator of this research, who always has had time for me and who gently guided me past pitfalls.

I also wish to express my thanks to Professor Tord Olin for his encouraging support, to Docent Göran Nylander for constructive discussions, enthusiasm and support, to my colleagues at the Department for smooth co-operation throughout the investigation, to Docent Lennart Leandoer, one of the promoters of this work, to Docent Göran Ekelund and Docent Clas Lindström for valuable collaboration throughout the study, and to Doctor Curt G. Carlbom for his scrupulous revision of the English text.

Moreover, I would like to express my sincere thanks to Mrs. Britt Nihlén and Mrs. Barbro Falkmer for secretarial assistance.

Furthermore, I am obliged to Mr. Hasse Kvist, Datacentralen, University of Lund, for patience, carefulness and invaluable professional help in processing data obtained during this investigation.

This study was made possible by financial support from the Swedish Medical Research Council (Project Nos B76-29X-04189-01, B77-29X-04189-02, B78-29X-04189-03, B79-04189-04 and B80-04189-05) and from the John and Augusta Persson's Foundation for Medical Research. Lund (Grant No. 1976/13).

This thesis is based on the following papers:

- I. FORK, F-T., EKBERG, O., NILSSON, G., RERUP, C. and SKINHØJ, A.: Colon-cleansing regimens. A clinical study in 1200 patients. *Gastrointest. Radiol.* 7 (1982), 1.
- II. FORK, F-T.: Reliability of routine double-contrast examination of the large bowel. A prospective study of 2 590 patients. Accepted for publication in *GUT*.
- III. FORK, F-T., LINDSTRÖM C. and EKELUND G.R.: The reliability of routine double-contrast examination (DCE) of the large bowel in polyp detection. A prospective clinical study. Submitted for publication in *Gastrointest. Radiol.*
- IV. FORK, F-T., LINDSTRÖM, C. and EKELUND G.R.: The double-contrast examination in carcinoma of the colon and rectum. A prospective clinical study. Accepted for publication in *Acta Radiol. Diagnosis*.
- V. FORK, F-T., LINDSTRÖM, C. and EKELUND G.R.: The double-contrast examination in inflammatory large bowel disease. A prospective clinical, radiographic, and pathologic study. Accepted for publication in *Röfo*.

These papers will be referred to in the text by their roman numerals, I - V.

ABBREVIATIONS

DCE - Double-contrast examination of the large bowel

BE - Conventional barium enema examination of the large bowel

UC - Ulcerative colitis

CDC - Crohn's disease of the colon

N - Normal

aN - abnormal

CONTENTS

	Page
INTRODUCTION	
General background	1
Aim of the present investigation	2
HISTORICAL REMARKS	3
THE ROENTGENOGRAPHIC PROCEDURE	6
DESIGN OF THE CLINICAL TRIAL	10
RESULTS	
Colon cleansing regimens, a clinical study in 1200 patients (I)	13
The diagnostic value of the routine double-contrast examination in large bowel diseases (II, III, IV, and V)	17
Interpretation of the follow-up procedures	19
The reliability of routine double-contrast examination of the large bowel (II)	20
The reliability of routine double-contrast examination (DCE) of the large bowel in polyp detection (III)	22
The double-contrast examination in carcinoma of the colon and rectum (IV)	28
Evaluation of the efficacy of the DCE in patients with and without neoplastic colorectal lesion (III, and IV)	33
The double-contrast examination in inflammatory large bowel disease (V)	34
Evaluation of the efficacy of the DCE in discriminating the colitic and non-colitic patients	44
GENERAL DISCUSSION	45
SUMMARY AND CONSLUSIONS	56
REFERENCES	59
ARTICLES I	77
II	101
III	121
IV	155
V	183

VIII

LIST OF TABLES

<u>Table</u>	<u>Page</u>
1. The relationship between test results applied to a defined population	12
2. Compositions of different colon-cleansing regimens previously to the examination	14
3. Number of patients as related to scores and regimens	15
4. The overall quality of the roentgenographic procedure and the obtained bowel-preparation scores	18
5. Evaluation of the effect of the DCE in defining the diseased and non-diseased patient	21
6. Number of patients with polyps diagnosed at DCE and at other diagnostic procedures	24
7. Number of neoplastic lesions in the large bowel according to site	26
8. Size and site of polyps not proved (n = 109), and overlooked (n = 95) at the index DCE	27
9. Site, size, grade of differentiation, and number of regional lymph-node metastases (Reg. Igll) in specimens with adenocarcinoma	30
10. Site, type, and depth of infiltration of 99 adenocarcinomas of the large bowel and number of specimens with regional lymph-node metastases (Reg. Igll). (+ = 1 lesion not specified)	31
11. False positive, 8, and negative, 11, DCE diagnoses for adenocarcinoma of the large bowel and true nature of the lesion	32
12. The colitis material	35
13. Predominant radiologic signs compatible with ulcerative colitis (UC) and Crohn's disease of the colon (CDC)	42
14. Type of colitis according to the pathologist's report on tissue specimens. Numbers denote patients with different radiographic diagnoses	43
15. The efficiency of DCE according to follow-up procedures and follow-up period	55

LIST OF FIGURES

<u>Figures</u>	<u>Page</u>
1. The routine DCE procedure according to the "Malmö method", A-D	8,9
2. The overall cleansing results in the three parts of the investigation	16
3. Male, born in 1952, with moderate diarrhoea. The DCE shows lymphoid hyperplasia but no signs of colitis	20
4. Male, born in 1933. The colon is adequately cleansed. An asymptomatic 3-mm large polyp is seen in the descending colon. The lesion was considered likely	23
5. The distribution of benign neoplastic lesions in the large bowel. Number of polypoid lesions, A. Number of proved tubular/tubulo-villous/and villous adenomas, B	25
6. The distribution of malignant and synchronous benign lesions in the large bowel. Number of adenocarcinomas and other malignant lesions, A. Number of proved, synchronous adenomas, B	28
7. Ulcerative proctitis with broadened rectal folds and increased retrorectal space, A. Ulcerative colitis with granular mucosa, uniformly afflicted. The rectal mucosa seems to be preserved, but the folds are broadened. Subsequent rectoscopy with biopsy revealed proctitis, B	36 37
8. Crohn's disease of the colon. Aphthoid ulcers in the left flexure, A. CDC with punched-out ulcers in the transverse colon and narrowing of the lumen in the lower descending colon and caecum, B. CDC with longitudinal ulcers and transmural changes in the transverse colon. Adjacent segments of the colon are almost normal, C	38 39 39
9. Male, born in 1960, with mild diarrhoea. The DCE shows "non-specific" changes in the descending colon and lower rectum.	40
10. Colitis with punched-out ulcers throughout the colon. An acute exacerbation led to total colectomy. Histopathologic examination of the organ revealed indeterminate colitis	41

INTRODUCTION

GENERAL BACKGROUND

Owing to the high frequency of colorectal diseases in the population of the Western Hemisphere, there has been a sustained effort by roentgenologists to improve the radiographic performance and technical quality of the large bowel examination (5, 12, 94, 95, 110, 165, 179). A variety of methods were soon described in the radiographic literature, and of which, the conventional barium examination (BE) (15, 33, 36, 37, 38, 63, 84, 85, 86, 97, 130, 166) and the double-contrast examination (DCE) of the large bowel (46, 64, 65, 66, 100, 111, 144, 145, 146, 163, 168, 189, 190, 191, 200, 201, 203, 204) became routine methods. Each of these two procedures has had its own spokesmen (142, 159, 182).

The consensus was that the BE was a rapid and safe technique, with high patient acceptance and also was considered to be unaffected by small amounts of retained faecal material (33, 63, 84, 85, 86). By using a compression spot-film technique and high kV, an accurate diagnostic yield was ensured, i.e. polyps were seen in up to 2.7 per cent of the patients examined (84).

With the DCE, tiny mucosal lesions were revealed to the extent that polyps in some series were seen in 12.5 per cent of the patients studied (205).

Advocates of the BE procedure expressed serious objections to the DCE. Their position was that the DCE was both time- and money-consuming, unpleasant and dangerous to the patient, and difficult to interpret (62, 63, 75, 86, 159).

Another important objection to DCE was that too many polypoid lesions were found, which were difficult to handle clinically. Only a small fraction of these polyps were suited for surgical removal, whereas the majority had to be followed up by repeat DCE after a certain period of time. This was, from a psychologic point of view, inconvenient and stressful for the patient. This situation was completely changed with the advent of colonoscopy (199, 215).

By compiling different series, the advantage of the DCE was indicated (155). With the introduction of the colonoscope, it was possible to compare the results obtained at radiography of the colon and rectum with those obtained at colonoscopy. The results of DCE's were again shown to be more accurate than those from BE's, regarding both the detection of polyps (155, 184, 197, 199, 213) and the disclosure of early mucosal changes in inflammatory disorders (18, 19, 89, 125, 126, 127, 196).

Owing to the successful results obtained with colonoscopy in both detecting and treating minor lesions, this method has, in many clinics, degraded the radiographic large-bowel diagnostic procedure to a second-class tool (45, 157).

The limited results that have been obtained in conjunction with radiography could be explained by difficulties in performance (84, 100, 145), in cleansing the bowel (46, 100, 111, 117, 146, 201, 202), in coating the bowel walls (85, 111, 190), in patient agreement (13, 146), and in difficulties in interpreting the roentgenograms, at least when the DCE was used (64, 65, 75, 100, 111, 142, 145, 146, 159, 190).

However, as recent reports have presented shortcomings of performance and of the diagnostic capacity of colonoscopy (41, 69, 77, 126, 127, 128, 131, 143, 183, 197, 214, 217), this procedure thus has not proved to be the ultimate answer as regards large bowel diagnostics.

AIM OF THE PRESENT INVESTIGATION

The diagnostic results obtained at DCE, according to the "Malmö method" at our institution, were hitherto regarded as reliable. However, the introduction of colonoscopy made it necessary to define the value of DCE in managing patients with large bowel disorders, above all, to analyze if the DCE was still justifying its position as the primary diagnostic method. It was thus believed to be worthwhile to try to define the clinical value of DCE: in terms of sensitivity, specificity, accuracy, and the predictive values of the

DCE - i.e. the possibility for the roentgenologist to discriminate patients with and without large bowel disorders (II); to reveal benign epithelial neoplasia (III); to disclose colorectal carcinoma (IV); and to diagnose colitis (IBD) (V).

One of the main difficulties in radiography of the large bowel is cleansing it of faecal debris, and this problem was dealt with separately (I).

HISTORICAL REMARKS

In his work "Eine neue Art von Strahlen" (1895), RÖNTGEN provided the key as to how to handle the problem of reproducing the gastrointestinal organs with the aid of X-rays. In this work some metals and their salts were arranged according to their capacity to absorb X-rays - results that were soon utilized in experimental investigations on gastro-intestinal organs of animals and man by STRAUSS and BECHER (1896). Additional gastro-intestinal studies were performed by CANNON and ROUX and BALHAZARD (1897) using bismuth-filled celluloid-coated capsules. Soon bismuth subnitrate was mixed with food, an idea that WILLIAMS (1901) was credited with (31, 36, 37, 38). This mixture was used in small doses by HILDEBRAND (1901) in his study of the large bowel in man.

In the pre-Röntgen era, the physical examination of the colon included abdominal palpation and percussion before and after air-insufflation per anum (191). The position of the large bowel could thus be determined with reference to adjacent parenchymatous organs and abdominal tumours. It was therefore natural that this technique, very early, was combined with roentgenographically obtained survey films of the abdomen (181, 216).

Thus, the first roentgenographic study of the large bowel in man was performed after insufflation of air into the large bowel by WILLIAMS (1901). GROEDEL, in 1909, recommended the bismuth clysma, as did HAENISCH in 1910 (1911, 1912), who stated that the enema was superior to the bismuth meal.

One of the first to publish roentgenograms of the colon with positive contrast in man was SCHÜLE (1904). However, not until RIEDER, in 1905, had proved that the ingestion of large amounts of bismuth salts was harmless - the RIEDER meal - was the roentgenographic investigation of the gastro-intestinal tract improved. Studies on topographic anatomy, physiology, and clinical observations employing roentgen rays soon appeared (105, 110, 161, 162) as did studies on radiologic signs of intestinal diseases (8, 106, 177, 181). Thus, in 1908, SCHENEK presented the first roentgenogram of a colonic carcinoma outlined by a contrast substance administered rectally.

In order to stabilize the bismuth, von GOURWITSCH (1912) suggested a suspension on mashed potatoes and syrup, given orally or rectally. He also used barium sulphate. This compound had been introduced by HOLZKNECHT (1906), but was not recognized as the contrast medium of choice until KRAUSE and SCHILLING (1913) reported on their experience with it. This compound had proved harmless, for it had previously been used as a filler to increase the amount and weight of flour.

In 1906, HOLZKNECHT recognized the importance of bringing out detail of mucosal lesions by external compression; and CASE reported on the benefit of "aimed" roentgenograms (1914); viz. a plate behind the screen exposed during the fluoroscopic examination, a technique later to be known as the "spot-film" technique.

The opaque clysma, with compression, spot-film technique, and fluoroscopy, was used in a large series of 500 patients as early as 1911 (29, 30). Also the necessity of turning the patients under fluoroscopic guidance to visualize the sigmoid loops was emphasized.

In an effort to reproduce the mucosal pattern in detail, KNOTHE, in 1927, used a small amount of barium and bowel evacuation before exposing the films. With the same aims as KNOTHE, KALKBRENNER, in 1928, introduced the thorium dioxide sol; and HAMILTON, in 1946, introduced the addition of tannic acid to the barium enema, which increased the adhesion of the barium to the mucous membrane.

Derangements compatible with signs of various disorders were described (15, 17, 36, 37, 38, 64, 65, 112, 117, 158).

The BE Procedure

In order to improve the diagnosis of small colorectal lesions, LEDOUX-LEBARD and GARCIA-CALDERON (1933) used a semi-transparent barium suspension, a technique already suggested by COLE and EINHORN in 1910. Overexposed films were recommended by RIEGLER and ERIKSEN (1936), and a high-kV technique in combination with a semi-opaque barium suspension by GIANTURCO (1950). This latter method was reported to be highly effective for diagnosing all diseases and abnormalities of the colon, including polyps and carcinoma (62).

The DCE Procedure

Another method for improving the reproduction of the details of the mucous membrane was developed by LAURELL (1922) and FORSELL (1927, 1928). They insufflated air or gas into the colon after filling the organ with barium. This technique led to development of the double-contrast technique (64) - a method combining an opaque barium suspension and air after bowel evacuation, and which results in a thin contrast layer sharply defining the mucosal surface on the roentgenograms. However, the folds of the mucous membrane practically vanished.

Compared with the BE, the DCE offered an advantage, as diagnostic roentgenograms could be obtained even when several loops were superimposed. In spite of this and the superiority of the DCE in demonstrating tiny lesions, the method was recognized by only a few but enthusiastic roentgenologists, KIRKLIN and WEBER (201), COLE (1932), GERSHON-COHEN (1933). However, in the 1950's, accumulating reports were published acclaiming the diagnostic advantage of the DCE. STEVENSON (1952, 1954) stated that the DCE was the most reliable diagnostic procedure, although 15 per cent of the studies were technically inadequate, mainly due to poor preparation of the right hemicolon. DOUGLAS (1953) opined that the DCE was the technique of choice for disclosing lesions above the rectoscopic level, and MORETON (1953) proposed it to be the single routine procedure.

However, the method was not adopted as a routine procedure. In spite of rather good results with the DCE, de PEYSTER and GILCHRIST (1955) preferred the barium enema, and other known gastrointestinal radiologists were adamant as regards their position on the superiority of the opaque enema and post-evacuation films (13, 80). GARLAND (1950) stated that the DCE was indicated in patients in whom polyps might be suspected. Further, the BE was said to be superior even in demonstrating the presence of ulcers, extent of disease, and skipped lesions in patients with Crohn's disease of the colon (139, 167). Although it was accepted that an optimal evaluation of patients with colitis was achieved when the BE, DCE, and post-evacuation films were utilized, the DCE was "suggested for those primarily interested in beauty" (139).

In Sweden, the methods and results of FISCHER and WEBER were adopted by WELIN and associates, and the DCE procedure was variously modified and improved and consequently became a routine of high quality - the "Malmö method" (1, 2, 142, 202 - 210). The good results obtained by this group were soon confirmed by ROSENZWEIG and HORWITZ (1958) and later summarized by GELFAND and OTT (1981).

THE ROENTGENOGRAPHIC PROCEDURE OF THE DOUBLE-CONTRAST ENEMA

From the double-contrast technique of FISCHER (1923, 1925) and BERG (1931), today's method of roentgen examination of the colon has evolved with only minor modifications (96, 100, 144, 203, 206). The same DCE procedure has been used for more than 25 years at Malmö General Hospital - with small changes.

The improvements comprise all the technical innovations since the mid 1930's, but also efficacious cleansing procedures (9, 10, 24, 25, 71) and better barium suspensions (96). Moreover, with the X-ray tube installed on a pendulum, it is possible to separate superimposed loops (160, 211) by angulation. Another advantage is the 1.5 m film-focus distance, facilitating the reproduction of fine mucosal details (204).

Unless otherwise stated, the patients are given 1.0 mg of

atropine orally (96, 204, 207) half an hour before the examination to stabilize the circulation. To reduce muscle spasm and induce bowel atonia in patients with diverticulitis or irritable bowel syndrome, Buscopan^R (butylscopolaminum bromidum) is injected, either 20 to 40 mg i.m. or 20 mg i.v. In most instances, then, the rectal balloon becomes superfluous.

The radiographic double-contrast examination of the large bowel is routinely carried out according to the schedule shown in Fig. 1 A to D. All the projections are adjusted fluoroscopically and are individualized according to patient anatomy and pathology, inter alia, with the CHASSARD-LAPINÉ's projection (32, 58). Any area of doubt is examined further.

In most instances the first, opening, single-contrast films (a barium suspension of 0.1 g% is used) and the post-evacuation films (31) are today considered dispensable. However, lumen-sized lesions in the left colon are readily identified in these films.

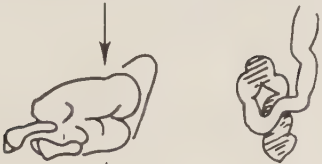
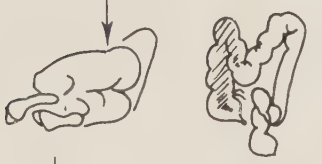
After bowel emptying, 300 to 400 ml of a high-density and low-viscosity barium suspension (54, 81, 107, 221) - 1.2 to 1.5 g% containing an antifoaming agent to prevent bubble formation - is given (72). To avoid flocculation and flaking of the barium coat (42) - promoted by water absorption from the suspension - the patient must be in a hyperhydrated state, i.e. 300 ml of tepid water is administered just before the air is insufflated.

In general, 12 to 14 roentgenograms are taken during the patient's first admission. However, the most valuable films are the true lateral ones of the rectum, the uncoiled sigmoid loops in RAO and LPO (160), the lateral decubitus cross-table beam films, and the erect ones. The horizontal beam films are obtained at the end of the DCE procedure, at which time any retained faecal mucous is wiped out and suspended in the dependant barium pool, with a clean, well-coated mucosa remaining.

In patients who are followed up, the follow-up DCE's comprise only 4 to 5 roentgenograms of the region of interest.

PATIENT POSITIONING		REGION OF INTEREST	FILM	COMMENTS
				Barium enema.
Right lateral			24 x 30 cm	True lateral of the rectum
RAO			24 x 30 cm	Sigmoid colon uncoiled. Cranial angulation of the tube
Prone			30 x 40 cm	Postevacuation film
Prone			24 x 30 cm	Hatched areas denote the barium pool. Cranial angulation of the tube. The rectum drained of barium.
RAO			24 x 30 cm	The sigmoid uncoiled. Cranial angulation of the tube
Right lateral			24 x 30 cm	True lateral of the rectum
LPO			24 x 30 cm	The sigmoid uncoiled. Caudal angulation of the tube. The barium pool has shifted to the rectum.
Chassard-Lapiné			24 x 30 cm	Only as a complement

Fig.1. The routine DCE procedure according to the "Malmö method" A-D.

PATIENT POSITIONING	REGION of INTEREST	FILM DIMENSION	COMMENTS
RPO		24 x 30	Only as a complement
RPO		30 x 40	Left flexure included
LPO		30 x 40	Sometimes caudal angulation of the tube to uncoil the cecum

Horizontal beam projections. Hatched areas denote the barium pool				
Right decubitus		30 x 40 cm	The rectum included	
Left decubitus		30 x 40 cm	The rectum included	
Erect		PA	35 x 35 cm	The flexures included
LAO		LAO	24 x 30 cm	The left flexure
RAO		RAO	24 x 30 cm	The right flexure and cecum included

The roentgenographic weak parts of the large bowel are the sigmoid and caecal regions. With our technique, six of the roentgenograms show major parts of the sigmoid colon (144) and at least three the caecum. All DCE roentgenograms are exposed at 100 kV, the exposure time and mA are given automatically.

In order to ensure good cross-table beam films, viz. to avoid grid cut-off, the grid cassette must be centred and the film-focus distance of 1.5 m be fixed. A wedge filter attached to the tube equalizes the film exposure between the dependent and non-dependent sides of the patients (43, 160).

DESIGN OF THE CLINICAL TRIAL

Background

Originally, the contemplated clinical test was intended to compare the results obtained at the BE with those obtained at the DCE in the same patient. This meant a modification of the radiographic procedures if the examination was to be performed on one occasion. This was, however, not possible because the first procedure influenced the second one. From an ethical and a practical point of view, it was not reasonable for the patients to be examined on two different occasions. Because the medical statisticians demanded that the radiographic examinations be conducted on the same patient - i.e. each patient was to serve as his own control - the idea of testing two different groups of patients was also rejected. Thus, in order to obtain a measurement of the diagnostic value of the DCE, a prospective study was designed with consecutive patients followed up carefully.

Performance

It was considered untenable to perform a colonoscopy or even a repeat DCE in order to achieve the highest degree of diagnostic accuracy in every patient. The only way to approach a reasonably high degree of diagnostic accuracy was to design a prospective trial that would continue for a couple of years. During this time the patients would be followed up clinically and when appropriate by repeat DCE and colonoscopy, surgery, and autopsy.

The duration of the follow-up period, minimally 40 months, was too short to allow minute lesions, i.e. benign epithelial neoplasia undetected at the index DCE, to cause symptoms (147, 148). On the other hand, a longer follow-up period would have yielded an increasing number of new polyps that would have detracted from the study. But the follow-up period was considered long enough to allow overlooked colorectal carcinomas at the index DCE to be detected, as they increase in diameter about 7 mm/year (53).

Another critical question concerned the diagnosis of colitis. The tendency of inflammatory lesions to fluctuate, i.e. with alternating periods of remission and exacerbation (141), is certain to cause interpretational difficulties. However, repeated follow-up studies in these patients would reduce the difficulties, although the tiny biopsy specimens obtained at endoscopy in most of these patients made the histologic examination less accurate.

In spite of these objections, it was considered worthwhile to initiate the trial. Malmö is especially well suited for clinical epidemiologic studies, as there is only one hospital for the treatment of somatic diseases. This hospital (Malmö General Hospital) serves a well-defined population with a small annual percentage of people moving into and out of the city, varying between 3.8 and 4.5 per cent during the last two decades. Furthermore, there has been a profound interest in colonic diseases at the surgical, pathologic, and radiologic departments during these decades (16, 18 - 23, 51, 103, 132, 133, 169, 203 - 210).

Comments on the Evaluation of the DCE

The radiographic diagnosis is as reliable as other medical tests and clinical diagnoses (226) and is well adapted for studies on decision analysis. The general theory of signal detection, based on probability theory and statistical decision theory, is helpful in defining the accuracy of a test (137).

When the test trial that is applied to a defined population is terminated, the test results can be assorted into true and false positive and negative diagnoses, as seen from Table 1, where TP = true positive, FP = false positive, TN = true negative, and

FN = false negative diagnoses (79).

TABLE 1.

The relationship between test results applied to a defined population

Test	Patients		Total
	diseased	non-diseased	
Positive	TP	FP	TP+FP
Negative	FN	TN	FN+TN
Total	TP+FN	FP+TN	Whole group

The test can now be defined as to:

1. Sensitivity: The number of TP's divided by the known number of diseased patients, $TP + FN$,
2. Specificity: The number of TN's divided by the known number of non-diseased patients, $FP + TN$,
3. Accuracy: The sum of the TP's and TN's divided by the whole group.

These parameters describe the possibility of identifying both the diseased and the non-diseased patient when the test is applied to a group of patients with the known presence or absence of a disease being screened for. But the parameters cannot describe the likelihood that a patient with a positive test is afflicted nor that a patient with a negative test is free from disease - i.e. how accurate the positive and negative test result is in the individual patient.

The validity of a positive result is described by the ratio between the TP's to the total number of positive tests, i.e.

4. Predictive value of a positive test. In the same way, the validity of a negative test is calculated as the ratio between the TN's to the total number of negative tests, i.e. 5. Predictive value of a negative test. These quotients express, in figures, the degree of reliability of the single test result - e.g. if the predictive value of a positive test is 0.85, then, this signifies that the test results are true in 85 instances of 100; and if a predictive value of a negative test is 0.99, the risk of a patient with a normal test being diseased is only 1 per cent (79). By applying these statistical parameters to the DCE, its clinical value was calculated: namely, the possibility of defining the patient with and without large bowel disease (II), colorectal polyps (III), colorectal carcinoma (IV), and colitis (V); but also the possibility of defining the predictive values of the DCE in different colorectal diseases, figures of interest to the clinician and vital for his patient (II - V).

COLON CLEANSING REGIMENS, A Clinical Study in 1200 Patients (I)

MATERIAL AND METHODS

Totally, 1200 consecutive patients who were scheduled, on a routine basis, for a DCE were included in this double-blind study. All patients had given their consent and were randomized.

All the regimens consisted of a 24-hour preparatory period and were identical as to dietary recommendations: viz. low-residue food and at least 2 litres of clear liquids. The compositions of the regimens are presented in Table 2.

The study was performed in a three-step fashion. The first part consisted of 600 patients, after which the results were analyzed. Three regimens were supplemented with additional saline and the second part of the study was started, and during this, an additional 2-liter tap-water enema was given to the last 180 patients, who comprised the third part of the study.

All the patients were studied with the DCE. The films were interpreted separately and judged with regard to colon cleansing by two

TABLE 2

Compositions of the different colon cleansing regimens given the day prior to the examinations.
The enemas were given on the day of examination

Compound	Regimen number											
	Part one						Part two			Part three		
	1	2	3	4	5	6	7	8	9	10	11	12
Magnesium oxide (g)							1.8	3.5	3.5	1.8	3.5	3.5
Sodium picosulphate (mg)			1.75	2.75	2.75	2.75						
			5	5	0	0 am. 10 pm.		5	10		5	10
Bisacodyl (mg)		10					10			10		
Bisacodyl microenema (mg)		10					10			10		
Cascara-Sagrada (mg)	60											
Magnesium-sulphate (g)		7.5										
Water enema (l)										2	2	2

TABLE 3

Number of patients as related to scores and regimens

Part 1		Regimen number					
		1	2	3	4	5	6
Cleansing score	Total 552	89	94	92	92	94	91
1	111	23	22	15	16	15	20
2	233	35	41	35	47	44	31
3	142	22	19	27	21	29	24
4	66	9	12	15	8	6	16

Parts 2 and 3		Regimen number					
		7	8	9	10	11	12
Cleansing score	Total 551	128	126	134	54	57	52
1	277	55	49	55	36	42	40
2	190	44	52	56	14	14	10
3	51	18	15	13	2	1	2
4	33	11	10	10	2	0	0

independent radiologists using a prearranged rating system.

A total of 97 patients were excluded because they had not been examined with the DCE or had failed to comply with the instructions. In 10 per cent of the evaluations of the roentgenograms, there was disagreement between the interpreting doctors, however, not exceeding one score number and without any particular tendencies.

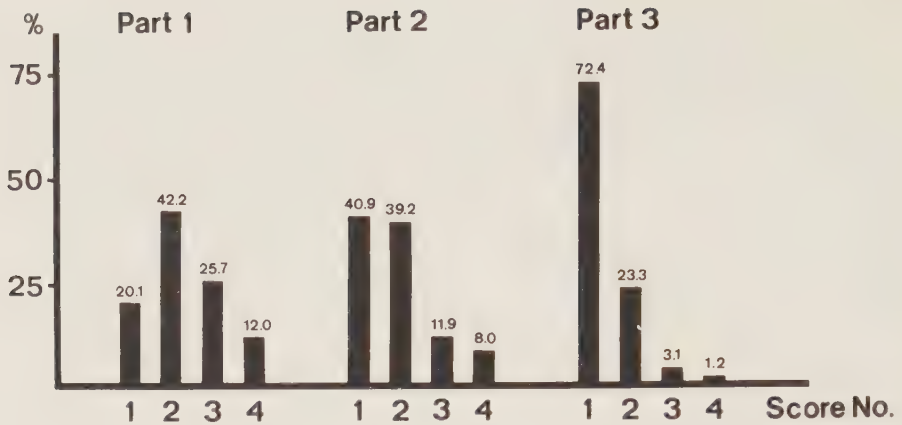


Fig. 2. The overall cleansing results in the three parts of the investigation given as percentages of patients with score number 1 to 4.

RESULTS

The regimens in the first part of the study were homogeneous as to cleansing scores. The same was true for the regimens in parts 2 and 3 (Table 3). When the fraction of patients with the best scores to the whole group in parts 1 and 2 were compared, a difference of highest significance was found. By comparing parts 2 and 3 in the same way, a difference of highest significance was again seen (Table 3 and Fig. 2), emphasizing the advisable combination of food restriction and hydration of the patient, a saline purge, and a final clyster.

The regimen group 9, in part 2 (Table 2), showed a higher incidence of adverse symptoms than the rest of the groups, among which no differences were shown. On the other hand, the number of patients complaining of bad taste and difficulty in carrying out the directions was significantly higher in regimen 1 than in the other ones. There was no difference regarding the number of evacuations in the groups or restriction in carrying out the daily work on the day of bowel preparation. However, 96 out of 552 patients in part 1 experienced such restriction.

THE DIAGNOSTIC VALUE OF THE ROUTINE DOUBLE-CONTRAST EXAMINATION
IN LARGE BOWEL DISEASE (II, III, IV, V)

MATERIALS

Patients

The clinical material originally consisted of 2590 consecutive patients, 1155 men and 1435 women, electively referred for the DCE. The examinations were performed within a 9-month period from May 1976. Because of severe medical or surgical disease in 55 debilitated patients, the BE was used. All other patients, 2535 were examined radiographically with the DCE, 389 patients studied with one, and 177 patients with two or more follow-up DCE's. One patient with a small carcinoma, which was surgically removed, was examined seven times.

METHODS

The Overall Quality of the DCE

In an attempt to estimate the diagnostic quality of the DCE procedure, every examination was classified according to an arbitrary system. The cleansing degrees were numerically scored into three groups, and notes with regard to the radiographic technique and the overall diagnostic quality were scored into four groups (Score 1, Adequate study; score 2, Some reservation; score 3, Poor; and score 4, Not acceptable). Patients with score 4 were not accepted in this analysis. The distribution of patients according to numerical scores is presented in Table 4.

TABLE 4.

The overall quality of the roentgenographic procedure and the obtained bowel-preparation scores. The scores are defined in the text

		Overall quality of the DCE			
		Score No.			
		1	2	3	4
Bowel preparation	Total				
Score No.	2535	1609	589	173	164
1	1907	1609	247	51	-
2	510	-	342	122	46
3	118	-	-	-	118

Interpretation of the Roentgenograms

In routine work the DCE studies are performed by junior radiologists in training and interpreted by a staff radiologist, who also provides a written diagnostic report. The study is then demonstrated to the clinician by another staff member.

During the first 3 months of this study, all the roentgenograms were, in addition, examined separately by two other independent radiologists, who were unaware of previous clinical and radiographic reports. Because the interpretations were highly concordant, the studies during the remaining 6 months were examined by only one radiologist.

If a positive result of a given examination did not accord with the previous, routinely written report, a new report was despatched, hence initiating follow-up studies. Data from these studies were collected and clinical records were scrutinized: rectoscopies (n = 378) in 336 patients (in 40 instances collected between June 1980 and March 1981); colonoscopies (n = 170) in 140 patients;

operative procedures (n = 155) in 145 patients; and autopsies of 137 patients were performed. The pathology reports (n = 793) were based on biopsy as well as organ tissue specimens from 650 patients.

Follow-up Period

The patients were followed up for 40 to 48 months, ending in June 1980. All radiographic, endoscopic, surgical, and histopathologic examinations during this period were collected. Patients with signs of colitis in whom no tissue specimens were obtained until the end of June 1980 were followed up for another 8 months.

Interpretation of Follow-up Procedures

A lesion was defined proved when it had been described as such by the pathologist: as verified when demonstrated on at least two occasions at the DCE or at colonoscopy, rectoscopy, or surgery. A single endoscopic examination was not considered sufficient to exclude the existence of an alleged lesion, which required the absence of any demonstrable change at repeat DCE or endoscopy. A disorder was overlooked when not depicted at the index DCE but later proved.

Pathology reports on total organ specimen were considered the ultimate answers as to whether a disorder of the large bowel existed or not. In the same way, reports on multiple biopsies were obtained from throughout the bowel through the colonoscope and were considered to be diagnostic.

In patients with a rectal lesion seen at the DCE or such a lesion discovered clinically, the reports from rectoscopies were collected and considered to give the ultimate answers as to the existence of a rectal disorder, if any.

Patients not further studied during the follow-up period, mean 44 months, were considered free of significant large bowel disease at the index DCE (first DCE).

THE RELIABILITY OF ROUTINE DOUBLE-CONTRAST
EXAMINATION OF THE LARGE BOWEL (II)

MATERIAL AND METHODS

This series included 2535 patients examined with the DCE. The index DCE in 164 patients was incomplete (118 due to improperly cleansed bowels and 46 due to difficulties in co-operation) and these patients were consequently excluded (6.8 per cent of total).

Each index DCE was classified as normal, N, or abnormal, aN. Patients with minimal abnormal findings at the index DCE (solely diverticulosis, 536; haemorrhoids, spasms, lymphoid hyperplasia (Fig. 3), etc., 92) were not included in the final synthesis of this series if no significant lesion was subsequently disclosed.

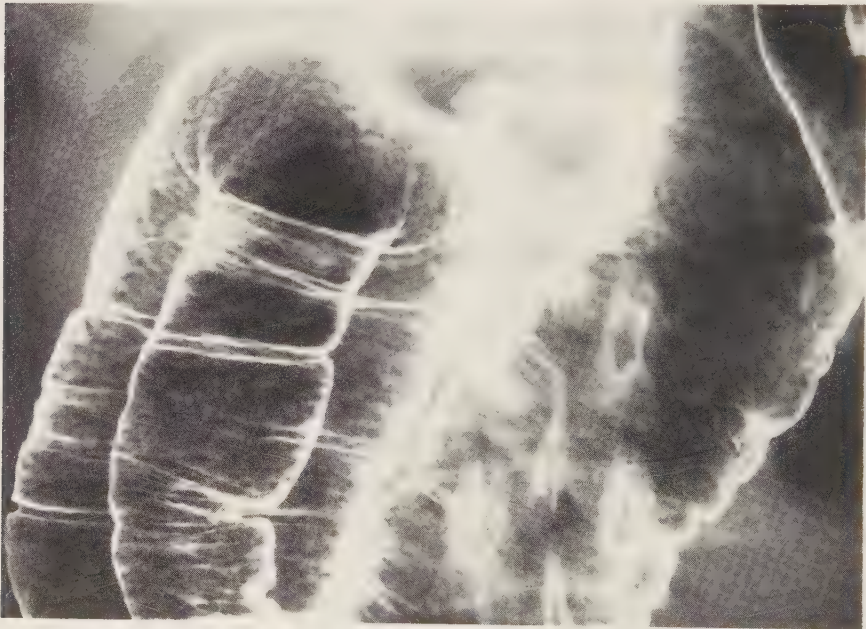


Fig. 3. Male, born in 1952, with moderate diarrhoea. The DCE shows lymphoid hyperplasia but no signs of colitis.

RESULTS

Patients With Follow-up Studies

Of the 2371 patients included in this analysis, 726 were examined with one or more follow-up procedures, viz. follow-up DCE's in 488 patients and histopathologic examination of tissue or organ specimens in 491 patients of whom 238 had had only one DCE study.

Patients Without Follow-up Studies

A total of 848 patients with a normal index DCE were not further examined. This was also the case in 181 patients with significant changes at the index DCE.

Evaluation of the Efficacy of the DCE in Defining the Non-diseased Patient

Of the 726 patients with follow-up studies, 461 were considered to have significant lesions, whereas according to the index DCE 265 did not. As a result of follow-up procedures, 509 of these patients did have large bowel lesions while 217 did not (Table 5). Thus, the sensitivity was calculated to 0.84, as was the specificity and accuracy of the index DCE report. The predictive value of a positive report was, in the same way, calculated to 0.93 and that of a negative one to 0.70.

TABLE 5.

Evaluation of the effect of the DCE in defining the diseased and non-diseased patient

Index DCE	Results from follow-up studies		Total
	aN	N	
aN	427	34	461
N	82	183	265
Total	509	217	726

The specificity rose to 0.93 upon accepting those 848 patients without any abnormal findings at the index DCE and not further examined during the follow-up period as being undoubtedly free of colorectal disease at the time of the index DCE (Table 15, p. 55).

THE RELIABILITY OF ROUTINE DOUBLE-CONTRAST EXAMINATION (DCE) OF THE LARGE BOWEL IN POLYP DETECTION (III)

MATERIAL AND METHODS

Patients

As in the preceeding series, 164 patients were excluded because of incomplete DCE studies. Moreover, 253 patients were excluded in this series (99 with adenocarcinoma of the large bowel and 154 with colitis). Thus, the analysis was based on 2118 patients.

Definitions

In addition to the aforementioned definitions (proved, verified, and overlooked), a polyp was considered likely when at the same DCE a lesion was seen at the same site in the bowel in at least three different projections, including one cross-table beam film (Fig. 4).

RESULTS

In 271 patients, 402 polyps were diagnosed of which 307 polyps in 222 patients were diagnosed at the index DCE (Table 6). Of these polyps, 109 in 74 patients were not proved. Upon reviewing the roentgenograms, 29 of these polyps in 28 patients, 6 of whom had no other polypoid lesion, were considered false positive errors of DCE. At follow-up examinations another 95 polyps in 71 patients were diagnosed, 49 of whom had no polyp depicted at the index DCE. In these 49 patients, 50 polyps were disclosed and considered false negative errors of the DCE. A total of 79 of the 95 additionally diagnosed polyps were up to 5 mm in diameter and only seven were more than 8 mm in diameter.



Fig. 4. Male, born in 1933. The colon is adequately cleansed. An asymptomatic 3-mm large polyp is seen in the descending colon. The lesion was considered likely. The patient refused colonoscopy.

TABLE 6

Number of patients with polyps diagnosed at DCE and at other diagnostic procedures.
Patients without, A, and with, B, coexisting carcinoma

Diagnostic procedure	Patients	Polyps	Probability	Cumulative total patients	total polyps
A					
Index DCE	148	198	proved		
	74 (46)	50	DCE-verified		
	(20)	30	likely true at DCE		
	(28)	29	DCE false positive	222	307 (index DCE)
Follow-up DCE	(22)	45	proved		352 (DCE's)
Other follow-up procedures	49	50	proved	271	402 (A)
Total follow-up	71	95	proved		
B					
Index DCE	15	38	proved	286	440
Other follow-up procedures	16	89	proved	302	529 (A + B)
Total B	31	127			

A retrospective analysis of the 71 index DCE's in patients with overlooked polyps (n = 95) revealed that 20 polyps in 14 patients were possible to see in retrospect, whereas 19 polyps in 12 other patients remained concealed in spite of adequate technique. In the remaining 45 index studies with false negative errors, these errors were mainly due to poor co-operation by the patient and, in a few instances, to inferior DCE's'

The distribution of polyps throughout the large bowel (Fig. 5A and Table 7) showed a predominance of polyps in the rectum and sigmoid colon. The majority of adenomatous polyps (n = 205) were histologically tubular adenomas (n = 150). These and the tubulo-villous adenomas (n = 47) were most frequent in the left hemicolon and in the rectum, whereas all but one villous adenoma (n = 8) were found in the rectum (Fig. 5B).

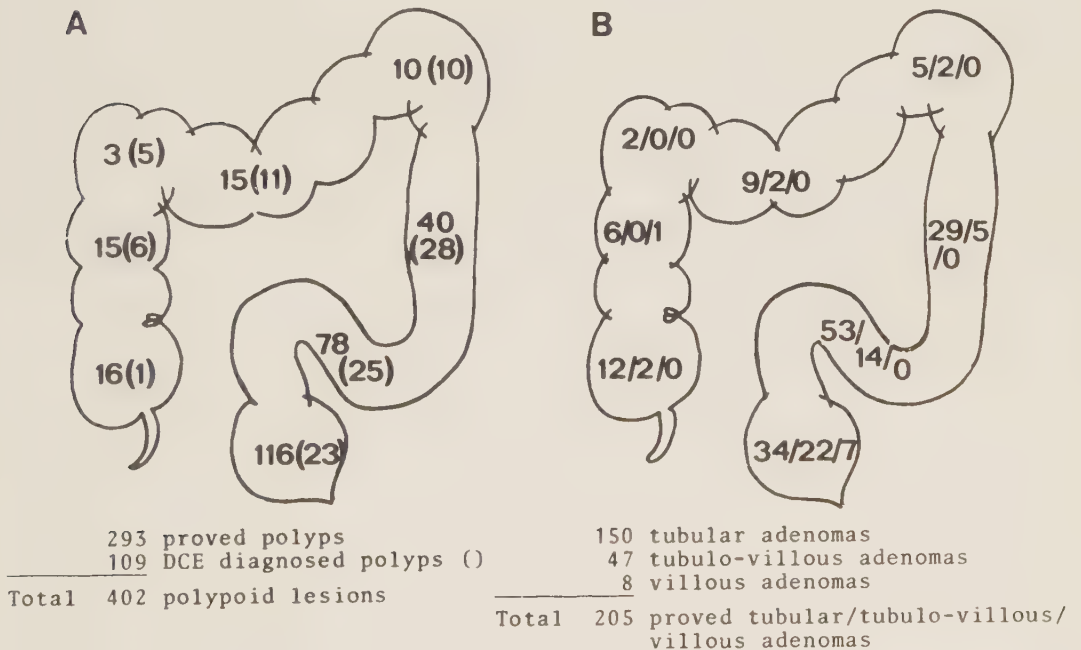


Fig. 5. The distribution of benign neoplastic lesions in the large bowel.

Number of polypoid lesions, A.

Number of proved tubular/tubulo-villous/and villous adenomas, B.

TABLE 7
Number of neoplastic lesions in the large bowel according to site

Site	Number of adenomas in patients		Total	Per cent of total	Number of adenoma coli and recti	Ratio adenoma/ carcinoma
	Without coexisting carcinoma	With coexisting carcinoma				
Caecum	14	28	42	12.7	16	2.6
Ascending colon and right flexure	9	37	46	13.9	8	5.8
Transverse colon, left flexure and descending colon	52	14	66	19.9	10	6.6
Sigmoid colon	67	16	83	25	33	2.5
Rectum	63	32	95	28.6	32	3.0
Total	205	127	332		99	3.4
Number of patients	161	31	192		96	(2.0)

In 74 patients, 109 unproved polypoid lesions were diagnosed at the DCE's. Of these, 50 lesions were subsequently DCE-verified. Thirty others were considered to be probably true polyps and 29 to be DCE false positives. Ten of these latter DCE-alleged lesions were found in 8 patients without any other lesion at the index DCE, while follow-up DCE's in 2 patients revealed proved polyps. The remaining 19 alleged lesions were distributed amongst 18 (of 222) separate patients (Table 6, p. 24).

A total of 73 of 109 polyps unproved were up to 5 mm in diameter; an additional 35 were up to 10 mm, and only one other polyp was up to 15 mm across (Table 8). Seventy-nine of the 95 polyps overlooked at the index DCE were 5 mm or less in diameter; a further 12 were up to 10 mm in diameter; and only four other polyps were up to 15 mm across.

TABLE 8

Size and site of polyps not proved (n = 109) and overlooked (n = 95) at the index DCE

Site	Total 109	Size of polyps (mm)						
		Not proved			Overlooked			
		≤5	-10	-15	≤5	-10	-15	
		73	35	1	Total 95	79	12	4
Rectum and sigmoid colon	48	35	12	1	58	47	8	3
Descending colon	28	14	13	-	9	8	-	1
Transverse colon	26	17	9	-	9	7	2	-
Caecum and ascending colon	8	7	1	-	19	17	2	-

THE DOUBLE-CONTRAST EXAMINATION IN CARCINOMA OF THE COLON AND RECTUM (IV)

MATERIAL AND METHODS

Patients examined with BE only were excluded ($n = 55$), whereas 2535 were included in this series. In 103 of these patients, 106 malignant lesions were found - in 53 women, mean age 70 years, and in 50 men, mean age 69.2 years.

RESULTS

In 103 patients with malignant lesions of the large bowel, 99 adenocarcinomas were found in 96 patients. In 7 patients other malignant lesions were revealed. The distribution of all lesions is shown in Fig. 6A - one patient with malignant lymphoma is not accounted for - and the sites of 127 synchronous adenomas in Fig. 6B. Of these polyps, 38 in 15 patients were disclosed at the index DCE (Table 6, p. 24), while 89 polyps in 16 patients were not.

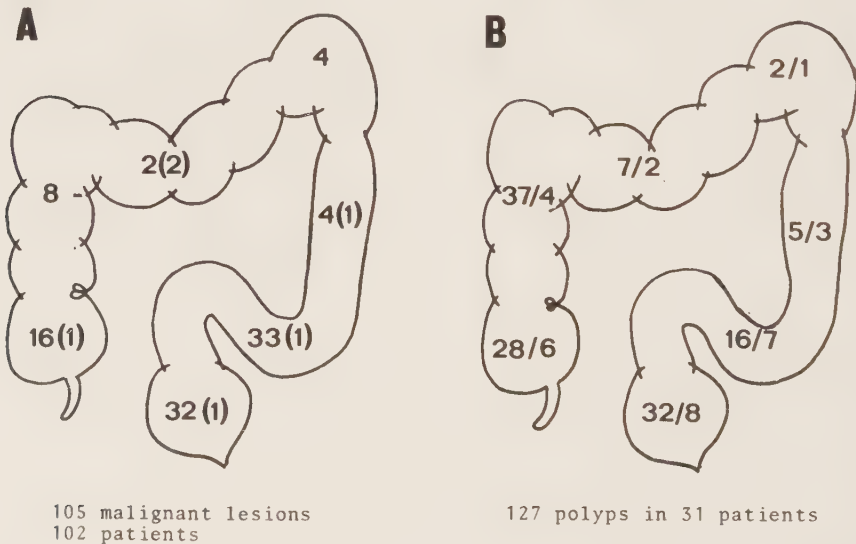


Fig. 6. The distribution of malignant and synchronous benign lesions in the large bowel.
Number of adenocarcinomas and other malignant lesions, A.
Number of proved, synchronous adenomas, B.

It is clear from Table 7 (p. 26) that the percentage of all benign adenomas assigned to each of five segments of the large bowel increased aborally, from 12.7 per cent in the caecum to 28.6 per cent in the rectum, while one-third of the adenocarcinomas were found in the rectum, one-third in the sigmoid, and the rest were distributed throughout the segments orally hereto.

Half of the synchronous adenomas ($n = 65$) were located in the right hemicolon, 12.6 per cent in the sigmoid colon, and 25.2 per cent ($n = 32$) in the rectum (Fig. 6B).

Small carcinomas, 10 to 30 mm across ($n = 18$) (Table 9), were mainly sited in the rectum and sigmoid colon ($n = 14$), whereas larger ones ($n = 81$) were evenly distributed throughout the large bowel. Two-thirds ($n = 65$) of all the carcinomas were found in the rectum and sigmoid colon (Table 10) as were 4 out of 5 carcinomas apparently originating from adenomatous tissue, eleven of 15 from tubulo-villous or villous adenomas, 5 of 6 with focal carcinoma confined to the epithelial layer, and solitary ones confined to the lamina propria and muscularis mucosae.

The frequency of local metastases in regional lymph nodes, seen in 45 organ specimens, increased with the decrease in grade of differentiation and with the depth of infiltration (Tables 9, 10). In only one specimen with a carcinoma originating from a benign adenoma were regional lymph-node metastases seen.

In 11 patients with adenocarcinoma of the large bowel, the lesions were not disclosed as malignancies at the DCE. The DCE diagnosis was diverticulitis in 3 and polypoid lesion in 5. In a patient with a recurrency, the lesion was interpreted as a normal postoperative anastomosis. In 2 other patients the lesions were not seen, one of whom had a DCE-depicted carcinoma elsewhere. This means that the existence of any manifest lesion was overlooked in 2 patients (Table 11). The size of these two lesions were 10 and 20 mm, respectively. In 8 other patients the existence of a large bowel cancer was falsely diagnosed at the DCE. Subsequently, benign adenomas were diagnosed in 6, an irradiation deformity in 1, and a normal mucosa covering an anastomotic region in another. At

TABLE 9

Site, size, grade of differentiation, and number of regional lymph-node metastases (Reg.lgll) in specimens with adenocarcinoma

<u>Site of tumour</u>	Total no of tumours	<u>Size (mm)</u>		<u>Reg. lgll</u>
		<u>10-30</u>	<u>>30</u>	
	99	18	81	
Rectum	32	7	25	
Sigmoid colon	33	7	26	
Descending to transverse colon	10	4	6	
Right flexure to caecum	24	0	24	
<u>Grade of differen-</u>				
<u>tiation</u>				
Well	34	11	23	9
Moderate	37	6	31	15
Poor	22	0	22	19
Not specified	6	1	5	2
Regional lymph-node metastases	45	2	43	

TABLE 10

Site, type and depth of infiltration of 99 adenocarcinomas of the large bowel and number of specimens with regional lymph-node metastases (Reg. 1g11).
(+ = 1 lesion not specified)

	Site				Reg. 1g11
	Rectum	Sigmoid colon	Descending to transverse colon	Right flexure to caecum	
Total					
99	32	33	10	24	45
Type of carcinoma					
From tubular adenoma	5	1	3	1	0
From tubulo-villous or villous adenoma	15	6	5	1	3
Ulcerating carcinoma	47	19	14	3	11
Polypoid carcinoma	16	4	3	2	7
Stricturing carcinoma	16	2	8	3	3
Depth of infiltration					
In situ	6 ⁺	3	2	1	0
Lamina propria	1	1	0	0	0
Muscularis mucosa	1	0	1	0	0
Submucosa	6	1	2	1	2
Muscularis propria	4	2	1	0	1
Subserosa	37	10	11	5	11
Through the serosa	43	14	16	3	10

re-operation a recurrent carcinoma was found in the tissue adjacent to this anastomosis. The false negative diagnoses (n = 11) were mainly due to small tumour size and the false positive diagnoses (n = 8) to lesions of large size (Table 11).

TABLE 11

False positive, 8, and negative, 11, DCE diagnoses for adenocarcinoma of the large bowel and the true nature of the lesions

	DCE Diagnoses	
	False positive for carcinoma	False negative for carcinoma
	A	B
Total	8	11
True nature of lesions, A		
DCE Diagnosis, B		
Benign adenoma	6	5
Diverticulitis	-	3
Normal anastomosis	1	1
Irradiation deformity	1	-
Carcinoma (overlooked)	-	2
Size (mm)		
< 20	1	5
> 20	7	6

The distribution of benign adenomas and adenocarcinomas in the two series of neoplastic disorders of the large bowel is synthesized in Table 7, p. 26). It is evident from this table that the number of adenomas and adenocarcinomas, as well as the quotient

between these lesions, varied with their location within the large bowel. Four patients had 38 benign adenomas and 6 others had 30. The majority of these polyps were found in the caecum, ascending colon, and right flexure. The remaining 264 adenomas were diagnosed in 182 patients. The quotients between benign and malignant lesions for neoplasia in the caecum, sigmoid colon, and the rectum were significantly less than for those in the remainder of the colon ($\chi^2 = 12.785$, d.f. = 2, $p < 0.01$).

EVALUATION OF THE EFFICACY OF THE DCE IN PATIENTS WITH AND WITHOUT NEOPLASTIC COLORECTAL LESION

Benign Adenomata

Totally, 373 benign adenomas ($n = 402 - 29$) (Table 6, A, p. 24) in 265 patients ($n = 271 - 6$) were either proved ($n = 293$), DCE-verified, or probably true ($n = 80$). Of these polyps, 278 ($n = 198 + 50 + 30$) were diagnosed at the index DCE in 216 patients ($n = 222 - 6$).

In patients with adenocarcinoma coli, 127 adenomas were proved in 31. Thirty-eight of these polyps were diagnosed in 15 patients at the index DCE (Table 6, B, p. 24).

A total of 500 polyps in 296 patients were thus disclosed during the follow-up period in 2217 patients. In 229 patients ($n = 214 + 15$) 316 adenomas ($n = 278 + 38$) were diagnosed at the index DCE. An additional 29 polypoid lesions were diagnosed at the index DCE but were considered to be false positives upon reviewing the roentgenograms. In all but 6 of these patients, the existence of additional polyps was proved.

By placing these figures into a decision matrix (79), the statistical parameters describing the validity of a test can be calculated. The sensitivity for disclosing every known polyp, regardless of size, at DCE was 63 per cent. The predictive value of a positive DCE for polypoid lesions was 91.6 per cent, which means that a positive DCE diagnosis was incorrect in 8.4 per cent.

In defining the patient without a polypoid lesion - the 2217 patients without a disclosed lesion during the follow-up period were considered to be free of adenoma at the time for the index DCE - the test results were as follows: sensitivity, 0.774; specificity, 0.997; accuracy, 0.970; predictive value of a positive DCE, 0.975, and that of a negative DCE, 0.966 per cent (Table 15, p. 55).

Adenocarcinoma

The clinical value and the validity of the DCE in carcinoma of the large bowel was calculated in the same way. In 8 patients the lesions seen at the DCE were falsely stated to be carcinomatous, whereas in 10 others the carcinomas were falsely diagnosed as "other benign lesion". Assuming that the 2424 patients without carcinoma diagnosed during the follow-up period were free of carcinoma at the time of the index DCE, the statistical parameters calculated were as follows: sensitivity, 0.903; specificity, 0.997; accuracy, 0.993; predictive value of a positive DCE for carcinoma, 0.921, and that of a negative DCE, 0.996 per cent (Table 15, p. 55).

THE DOUBLE-CONTRAST EXAMINATION IN INFLAMMATORY LARGE BOWEL DISEASE (V)

MATERIAL AND METHODS

Patients

The same 2371 patients as in series II were included in this analysis. Of these, 154 had clinical and/or radiographic signs of inflammatory colorectal disease. However, due to an error in allocating 3 patients according to numerical scores, these patients were excluded afterwards because of poor preparation, thus leaving 151 patients for this series (Table 12).

In 65 other patients with subtle clinical and radiographic signs and symptoms of colitis, the pathologist reported on non-specific colitic changes other than UC or CDC in endoscopically obtained biopsies. These patients were henceforth referred to as having

"non-specific" colitis. In one patient changes were referred to as indeterminate colitis after histopathologic examination of the resected large bowel.

In the remaining 17 patients, specific causes to the colitis were found.

TABLE 12.

The colitis material

Diagnoses	No. of patients	Age*	Available specimens from		
			No. of patients	No. of occasions	No. of organ specimens
UC	44	median 32.5	40	61	8
CDC	24	" 30.0	20	40	13
Non-specific colitis	66		58	83	6
Specific colitis	17		16	20	10
Total	151		134	204	37

* Mean age = 35.0 years

Radiographic Diagnosis

The radiographic signs forming the basis for the radiographic diagnoses, i.e. the distribution, depth of the lesions, and contour of lumen, are listed in Table 13 and the DCE findings representative for UC and DCE are shown in Figs 7, 8, 9 and 10.



Fig. 7A. Ulcerative proctitis with broadened rectal folds and increased retrorectal space.



Fig. 7B. Ulcerative colitis with granular mucosa, uniformly afflicted. The rectal mucosa seems to be preserved, but the folds are broadened. Subsequent rectoscopy with biopsy revealed proctitis.

Fig. 8A



Fig. 8. Crohn's disease of the colon. Aphthoid ulcers in the left flexure, A.
CDC with punched-out ulcers in the transverse colon and narrowing of the lumen in the lower descending colon and caecum, B.
CDC with longitudinal ulcers and transmural changes in the transverse colon. Adjacent segments of the colon are almost normal, C.

Fig. 8B and C





Fig. 9. Male, born in 1960, with mild diarrhoea. The DCE shows "non-specific" changes in the descending colon and lower rectum.



Fig. 10. Colitis with punched-out ulcers throughout the colon. An acute exacerbation led to total colectomy. Histopathologic examination of the organ revealed indeterminate colitis.

TABLE 13

Predominant radiologic signs compatible with ulcerative colitis (UC) and Crohn's disease of the colon (CDC)

	UC	CDC
Localization	Left-sided	Right-sided
Rectal involvement	Often	Seldom
Ulcers, "early stage"		
Borders	Blurred	Sharply outlined
Depth	Superficial	Aphtoid
"Chronic stage"	Submucosal, dissecting	Transmural, ragged ulcers, fissures, fistulas, sinus tracts
"Fulminant-toxic stage"	Transmural	As above
Distribution	Continuous, symmetrical	Discontinuous, asymmetrical
Mucosal detail	Granular, "stippled" appearance	"Normal" between ulcers. Solitary nodules, "cobblestone" appearance
Involvement	Uniformly, symmetrical	Eccentrically, asymmetrical
Contour of lumen	Uniformly narrowed. Loss of haustral folds	Asymmetrically narrowed, localized strictures, "pseudodiverticula"
Terminal ileum	Normal or dilated	Superficial to transmural changes, strictures
Ileo-caecal valve	Open	Swollen, stenotic

Tissue Specimens

In 40 patients with signs of UC at DCE and in 20 with signs of CDC, tissue specimens were available. (Table 12), which were obtained through surgery in 21, through the colonoscope in 24, and through the rectoscope in 56 patients. In 58 out of 66 patients with non-specific colitis, tissue specimens from 83 different occasions were available, including six operations.

RESULTS (Table 14)

In 40 patients with radiographic signs of UC, the examination of the available tissue specimens confirmed the diagnosis in 26, diagnosed 2 patients as normal, and disclosed non-specific colitis in 12 others.

TABLE 14

Type of colitis according to the pathologist's report on tissue specimens. Numbers denote patients with different radiographic diagnoses

Radiographic diagnoses	Total 118	Histologic diagnoses			
		UC/CDC	Non-specific colitis	Specific colitis	No colitis
UC	40	26	12	-	2
CDC	20	13	6	-	1
Non-specific colitis	45	3 ⁺	30 ⁺⁺	6	6
No colitis	13	-	12	1	-

Total agreement: UC 26/40 = 65 %
 CDC 13/20 = 65 %
 Non-specific colitis 30/45 = 66.7 %

⁺ = histologic indeterminate colitis, 1; CDC, 2.

⁺⁺ = histologic probably UC, 6; CDC, 4.

In 20 patients with CDC at DCE, the diagnosis was confirmed in 13, referred to as non-specific colitis in 6, and not confirmed by the pathologist in 1.

In 45 patients with radiographically non-specific changes attributed to colitis, tissue specimens were available revealing various colitic changes in all but 6. In 30 instances non-specific colitis was reported by the pathologist; however, in 6 of these instances, UC was suggested and in 4 CDC. In one patient the organ specimen revealed profound, indeterminant colitic changes (Fig. 10). In 2 patients, already accounted for, signs of CDC were reported, and in 6 others miscellaneous findings were seen (postradiologic colitis in 4, solitary ulcer in 1, and mucosal inflammation in a patient operated on for rectal carcinoma).

In 13 radiographically normal patients, tissue specimens from endoscopic biopsies revealed non-specific inflammatory changes.

The overall diagnostic accuracy according to type of non-specific colitis is given in Table 14, i.e. for UC 65 per cent and for CDC 65 per cent. In half of the cases with histologically non-specific colitis ($n = 60$), this was also seen radiographically.

Evaluation of the Efficacy of the DCE in Discriminating the Colitic and Non-colitic Patient

Accepting only those patients in whom pathology reports on tissue specimens were available during the follow-up period and excluding those with a main radiologic lesion other than chronic non-specific colitis or those with an inferior bowel preparation, i.e. 118 accepted patients out of 154, and assuming patients not further studied to be free from colitic changes at the index DCE, i.e. 2335 ($n = 2371 - (154 - 118)$), the diagnostic possibilities of detecting colitis at the DCE judged by a subsequent pathology report on tissue specimens was as follows: sensitivity, 0.89; specificity, 0.996 and accuracy of the DCE, 0.991. The predictive value of a positive DCE was in the same way calculated to 0.91 and that of a negative DCE to 0.99 (Table 15, p. 55).

GENERAL DISCUSSION

The test providing the ultimate answer as to which roentgenographic procedure in examining the large bowel is the more efficacious, viz. the single- or the double- contrast examination, has still not been presented (154). Today, colonoscopy is more and more frequently requested by referring physicians for both patients without previous radiographic examination of the large bowel and patients with normal radiographic studies. This mode of procedure is justified by series, continuously being published, presenting limited figures on sensitivity of radiographic examinations in different colorectal disorders when compared with colonoscopy, stating the superiority of the latter (41, 78, 131, 155, 183, 197, 214), but also the diagnostic advantage of the DCE to the BE. But as colonoscopy so far is available only at a few clinics and is attended by certain risks and difficulties (76), as well as diagnostic limitations (69, 70, 143), colorectal examinations still frequently are based on radiography. This means that the question, Which of the methods to use, the BE or the DCE? is still a valid one.

Thus, because radiography is a diagnostic procedure that is available in most clinics it is necessary that this method be as accurate as possible also in disclosing colorectal disease. This, then, would indicate that colonoscopy may mainly be used as a therapeutic tool in clinics with an endoscopic department rather than as a diagnostic tool (88) and that the two methods - DCE and colonoscopy - should be regarded as complementary and mutually supportive (136, 224, 225).

A compilation of a large number of series on radiography of the large bowel indicates that the DCE is the most sensitive procedure in polyp detection (82). Thus, according to the literature, the DCE ought to be the routine radiographic procedure whenever diseases of the large bowel are to be explored. An infrequently performed DCE is seldom of adequate diagnostic quality (143). It was thus necessary to label the diagnostic quality of DCE in biostatistic terms (79), i.e. to account for the advantages and shortcomings of the test in general screening for colorectal diseases, as well as

state and or exclude the diagnostic accuracy of lesions at the DCE in the individual patient. At our hospital, the DCE has been a routine method since 1955; and to date, more than 100,000 DCE's have been performed.

The initial aim of the present study was to compare the diagnostic yield obtained at the DCE and the BE in the same patient at the same referral. Certain modifications of the examination procedure had to be introduced, but in spite of intense efforts the original design of this trial had to be rejected. This was mainly because the "double-blind" condition could not be fulfilled and also because the combined radiographic procedure could not be elaborated into a routine. Thus, the first procedure influenced the second one in a certain number of cases, which had to be rejected. From a statistical point of view, it was deemed unacceptable to compare two different groups of patients examined radiographically with the BE and the DCE, respectively

Thus, to assess the diagnostic yield of DCE, a large group of patients examined with the DCE had to be followed up carefully during a reasonably long period of time. This period should be long enough to allow any significant colonic disorder missed, e.g. malignant or inflammatory lesion, to be detected; but the period should be short enough not to be substantially influenced by "new" benign lesions, such as adenomas, which occur after an average of 100 months (20, 51).

Based on the known prevalence of colorectal disorders in our group of patients, some 2500 consecutive patients were estimated to be followed up during approximately 48 months yielding arbitrarily 50 patients with new carcinomas, 100 with polyps, and 150 with colitis per annum.

Examination of total organ specimens was considered to give the ultimate answer as to whether any colorectal disorder existed or not. Next to this examination, colonoscopy with biopsy of the whole colon was accepted as giving the clinical truth, whereas rectoscopic examination only disclosed conditions in the rectum. Finally, a follow-up DCE was considered to support or reject a

finding at the first, index DCE.

In evaluating the clinical efficacy of DCE, the statistical calculations were mainly based on patients studied with any follow-up method, but the figures based on all those patients with a normal index DCE and with no sign of disease during the follow-up period, i.e. not examined further, were also given.

In order not to be biased, all the roentgenograms were read by radiologists who were unaware of clinical, endoscopic, and previous radiographic studies. The patient's history and clinical findings were recorded separately, as was the type of bowel preparation employed. At the interpretation of the roentgenograms, the technical quality, quality of the examination procedure, moving artefacts, etc., were recorded and the overall diagnostic quality was arbitrarily scored numerically 1 to 4. Studies with a score of 4 were not accepted. After the recording procedure, the diagnoses made were compared with those made at the routine interpretation. In cases with a positive finding at the final reading, the clinician was informed, thus obligating him to perform or ask for follow-up examinations or surgical intervention.

In four series (II - V), 55 patients were excluded because they had been examined with the conventional barium enema only, and therefore they did not fulfill the criteria for this study. These patients usually were senile and/or suffered from severe generalized disease, and in whom only a stricturing lesion had to be excluded. In series II, III, and V, another 164 patients were excluded, 46 because they could not co-operate, were debilitated or crippled, and 118 patients who did not comply with the instructions for bowel preparation. This meant that only 8.5 per cent of the patients routinely referred for the double-contrast examination of the large bowel were not suited for this examination - due to either a medical disorder or unclean bowels. Considering the non-selected patient material, consisting of both in- and out-patients of all ages, this percentage of failures seemed to be reasonably low.

Bowel Cleansing

For centuries, spring waters that were able to induce bowel

movements were held in good repute. Soon, their contents of mineral salts were credited for the salutary effect. In spite of this knowledge, mineral water was ignored when recommendations were made as to bowel preparations before roentgenography. Instead, castor oil alone, or with various combinations of food restriction and/or tap-water enemas, was recommended (33, 65, 144, 190, 200).

However, not until 1961 when BROWN and again in 1968 when BARNES reported on a new approach to obtain a clean colon was the efficient combination of hydration and saline on bowel movements re-discovered. Cold magnesium citrate in solution was given together with water and bisacodyl orally the day before large bowel radio-graphy and was supplemented with bisacodyl rectally in the morning. Only low-residue food was allowed 24 hours before the examination.

During the last decade, the routine bowel preparation in our department consisted of a combination of hydration of the patients, low bulk diet, saline purge, and a contact laxative* (Cascara-Salax) given orally twice the day before the roentgenographic study. Cleansing degrees varying from 54 per cent in patients to 95 per cent have been reported (9, 10, 24, 25, 170, 178) with the same or similar preparations.

Several oral laxatives have been tried in order to simplify the cleansing procedure, to dispense with the "irrigation personnel" (9, 10, 24, 25, 170, 178), and to cut down on expenses. However, in daily work, patients were frequently given a tap-water enema in spite of the hydration technique.

The whole-gut irrigation with an electrolyte solution administered via a duodenal tube (101) was considered too vigorous for routine use in unselected cases.

In the first part of the investigation, two standard cleansing systems were compared (bisacodyl orally and rectally, and Cascara-

*Two tablets of Cascara Sagrada, each equal to 30 mg of antraquinone glycoside and 7.5 mg of magnesium sulphate, morning and afternoon.

Salax) with sodium pico-sulphate, an efficient regulator of bowel movements and of stool consistency (59, 67, 108, 180). Each was given orally in an original composition of powder with magnesium citrate. No significant difference was seen. When, however, salt was added to the first and increased in amount by 30 per cent in the latter two, the cleansing effect of all three medications improved significantly.

Although the number of patients with excellent and sufficiently cleansed bowels increased significantly when the saline was increased, the dramatic clinical amelioration was seen when a final tap-water enema was included. A very high degree of acceptably cleansed patients was then achieved in patients pretreated with food restriction and hydration. Thus, the optimal cleansing effect is still achieved when the oral regimens are finally completed by personnel who know how to handle an irrigator.

Neoplastic Lesions of the Large Bowel

Roentgenography was applied early in the search for carcinomas of the gastro-intestinal tract. HOLZKNECHT, in 1906, suggested abdominal palpation and observation of peristaltic movements during fluoroscopy in order to disclose neoplastic lesions, and HAENISCH, in 1911 and 1912, suggested the usefulness of fluoroscopy during rectal instillation of the contrast medium. This was again emphasized by WEBER in 1933. He also reported the advantage of the "air-distended bowel" in delineating small polyps - "the earliest stage of a malignant process, which a roentgen method can uncover". The significance of polyp detection was strongly indicated by BUIE in 1937, who stipulated malignant transformation of all colon polyps, if they "are not destroyed or the patient lives long enough". SWINTON, in 1939, could demonstrate a benign origin in 14 per cent of the malignancies found, an observation confirmed by AULT in 1952 and WELIN in 1958. In our series, 20 per cent of the malignant tumours were found to be apparently of benign origin. The role of the radiologist in managing patients with neoplastic lesions of the large bowel was emphasized by many authors (1, 2, 14, 33, 63, 85, 146, 193, 203, 204). To repeat the BE study was strongly recommended in patients with obscure bleeding (33, 193) or in patients with a suspicious lesion at the BE or the DCE (146), in

patients with normal sigmoidoscopy and rectal bleeding (14), and in cases with retained faeces, which was often impossible to differentiate from polyps (46, 111, 227).

In the 1950's the radiographic technique was said to be so effective that the problem was "no longer one of detection of polyps but rather the management of these" (63). However, studies on accuracy of the colon radiography in large bowel carcinoma revealed some 10 per cent failures (39, 123). Another significant obstacle to increasing the cure rate of large bowel carcinoma was said to be the patient himself, who did not always present himself early enough, but also the radiologist and clinician who were not "polyp conscious" (175, 191).

The theory stating the colonic carcinoma originates from a benign polyp has been generally accepted (47, 48, 49, 50, 55, 56, 57, 67, 68, 87, 88, 92, 98, 109, 103, 147, 148) while a few authors believe that they arise de novo (186, 187). This latter hypothesis has never been proved except for precancerous adenomatous tissue (27, 120, 121, 122). In spite of the fact that the incidence of adenoma exceeds that of cancer, MORSON, in 1974, claimed that there is strong scientific support that these benign lesions have malignant potential. The evolution of the polyp-cancer sequence was to be influenced by polyp size and type, the incidence approaching 50 per cent in adenomas 2 cm or more in diameter and 40 per cent when villous in type (147, 148).

Recent experiences with large numbers of adenomas removed through the colonoscope also speak in favour of adenomatous tissue as being precancerous (222 - 225). Because there is no definite macroscopic sign of malignancy in predominantly benign neoplastic lesions, all neoplastic lesions should be removed when diagnosed (88, 215).

In the present investigation 13.4 per cent of the patients were found to have benign polypoid lesions, 67 per cent of which consisted of adenomatous tissue, precancerous for sure. In no other series based on conventional radiography of the large bowel, i.e. the BE, has an incidence of approximately the same magnitude been

presented (63, 84, 86). In 7 per cent of adenomatous polyps in this series, malignancy was suspected at the histopathologic examination, and 6 per cent of the adenocarcinomas were polypoid in shape and less than 22 mm in diameter. It was also shown that 15 per cent were adenomatous in origin. These findings are approximately in agreement with those reported in other series (34, 56, 57, 78, 92, 98, 113, 147, 148, 153, 194, 195, 203, 208, 218, 222, 224), but less than those reported by MUTO et al. (1980), and emphasize the necessity of early polyp detection. The DCE as a routine radiographic procedure in exploring the colorectum has proved to be an efficacious method in diagnosing polypoid lesions, as has been shown earlier (1, 14, 185, 206, 213). Because 30 per cent of lesions primarily overlooked at DCE are seen in retrospect (69, 155, 213, 214), every DCE ought to be double checked.

In this series it was also shown that the quotient between the number of benign adenomas to adenocarcinomas was significantly less in the caecum, sigmoid colon, and the rectum when compared with the rest of the large bowel. This might indicate that the benign epithelial neoplasia in the caecum, sigmoid colon, and rectum have a greater tendency to undergo malignant transformation (40). This finding was supported by the observation that 17 out of 20 (5 + 15) carcinomas arising from benign adenomas were found in these areas.

It has been shown that patients with Dukes' stage-A cancers have favourable survival rates (16, 48, 60, 147, 148, 149), which is particularly true for patients with intramucosal carcinoma (52, 61, 74, 78, 119, 171, 188, 214, 224, 225). These "early" cancers are seldom symptomatic (99, 190) and may thus be found only by applying colonoscopy or large bowel radiography on the asymptomatic patient.

A new approach to search for colorectal neoplasia was introduced with the Hemoccult slide test, with smears being made over a 3-day period (3, 91). In about 50 per cent of patients with a positive Hemoccult test, colorectal neoplasia were found - carcinomatous in 30 per cent and benign polypoid in 70 per cent (219, 220).

Hemoccult screening programmes for colorectal disease have increased the demands for clinically efficient follow-up examination procedures for exploring the colorectal mucosa, i.e. colonoscopy and large bowel radiography. Although the possibility of separating the diseased patient from the non-diseased one is considered higher for colonoscopy (41, 70, 77, 127, 128, 131, 156, 183, 197, 214, 224), the possibility of examining a large group of patients is generally higher with roentgenography than with colonoscopy, except in endoscopically highly trained hands (155).

In the present series the diagnostic errors resulting at the DCE in diagnosing the malignant lesion were not that of denying the existence of a lesion, but that of not predicting its true histologic nature ($n = 14$), i.e. 7 true carcinomas, one carcinoid and 6 benign polyps. All of these lesions ought to have been removed anyhow and were so on the basis of the DCE findings. There were, however, 5 patients in whom the DCE findings were misinterpreted: The malignant lesion was denied in 3 patients (one of them having another carcinoma diagnosed at DCE, one a local recurrency, and another an overlooked 10-mm tumour) and suggested in the remaining 2 patients (one with an irradiation colitis and the other with a recurrent carcinoma in the adjacent tissue without any mucosal engagement).

From practical and clinical points of view, the errors numbered only 2, i.e. one carcinoma was diagnosed at autopsy 3 months later in a patient with diverticulitis and the other carcinoma, 20 mm, was diagnosed at colonoscopy. The false positive diagnoses were all easily handled at endoscopy.

Colitis

The aetiology of chronic non-specific inflammatory bowel disease is still not known. Although there are clinically and histopathologic markers differentiating UC and CDC (115, 134, 135, 138, 139, 140), there are a number of cases in which a confirmatory diagnosis is not achieved (23, 134, 138, 164, 172, 176). In a prospective study, like the present one, the diagnostic insecurity, to a great extent, is explained in part by the tiny pieces of tissue from endoscopic biopsy procedures on which the pathologist

had to report on and partly on the varying courses of the two diseases (141). On the other hand, the reliability of microscopic diagnosis in organ specimens is close to 90 per cent. In about 10 per cent of the cases, indeterminate features are seen (23, 134, 138, 164, 172, 176).

Since the biopsy specimens of apparently normal mucosa sometimes will reveal microscopic signs of inflammation (11, 104, 136, 152) and since endoscopic specimens from patients with clinically and radiographically CDC only occasionally will disclose granulomas, the true nature of inflammatory bowel disease must rely on accumulated data from repeated clinical observations and from radiographic, endoscopic, and microscopic examinations (104, 114, 134, 136, 138, 150, 152, 172, 196, 198, 212).

There are inherent difficulties in clinical studies designed for this purpose in patients with colitis. A number of patients will present borderline symptoms and signs that do not occasion supplementary examinations. Thus, a diagnosis of the alleged lesions was not obtained in 10 out of 55 of our patients; secondly, 6 out of 66 patients were lost in spite of an intense search for them; thirdly, the tissue specimens available are predominantly biopsies from endoscopic procedures, i.e. tiny and often too small for the pathologist to obtain a clear-cut histologic diagnosis (138). In the present study, only 37 organ specimens were available for histopathologic examination.

In patients with ulcerative proctitis, the typical histologic picture is that of a non-specific inflammation (150), which means that in 12 patients with radiographically UC, this could be compatible with the pathology report (Table 13, p. 42).

Another interpretational difficulty is the possible remitting courses of the diseases with clinical restitution within weeks (116, 172).

In 55 patients with non-specific colitis at the DCE, the radiographic signs were vague and confined to distal segments of the large bowel. These signs were mainly "faint granularity of the

mucosa" alone or in combination with "shallowness of the rectal folds" (45 cases). In 30 of these patients, non-specific colitis was seen histologically, which could indicate ulcerative proctitis, a diagnosis not contradicted by radiology (125, 126, 184, 209).

With reservation for the above-mentioned objections due to the design of the clinical trial, it was considered justified to present the accumulated number of patients with and without colitis when calculating the diagnostic accuracy at the DCE as regards the existence or absence of inflammatory bowel disease.

It is also worth noting that no patient with a normal DCE has developed an established inflammatory bowel disease during the observation period.

Evaluation of the DCE

The main difficulty in accounting for the accuracy of any test is in defining the non-diseased patient and, above all, in defining the absence of an asymptomatic lesion. A follow-up period will, in the long term, reveal the afflicted patient, whereas the overlooked and slow-growing lesion is difficult to exclude if total exploration of the colorectal mucosa is not performed in every "normal" patient included in the test. The combined use of follow-up procedures performed in patients on clinical indications and of a follow-up period over several years was used in this series in which the patients were searched for as thoroughly as possible.

This study has documented that 84 per cent of patients with colorectal disease were discovered at the DCE, as were 93 per cent of non-diseased ones in a clinically selected group of patients with a 30 per cent prevalence of colorectal disease (509 diseased patients of 1574).

The possibility of defining the various types of colorectal disease at the DCE - in accordance with the histopathologic diagnosis - ranged between 78 per cent for polypoid lesions and 90 per cent for cancer. At the same time, the specificity was calculated at 93 per cent in stating the absence of colorectal disease and at 99 per cent in excluding the absence of a neoplastic benign

TABLE 15

The efficiency of DCE according to follow-up procedures and follow-up period

DCE-test evaluation	Colorectal disorder		
	The afflicted patient	Benign epithelial neoplasia	Carcinoma Chronic non-specific colitis
Sensitivity	0.84	0.78	0.90
Specificity	0.93	0.99	0.99
Accuracy	0.93	0.97	0.99
Predictive value of a positive DCE	0.93	0.98	0.92
Predictive value of a negative DCE	0.93	0.97	0.99
Total number of patients studied	1574	2217	2535
Prevalence of disease (%)	32	13	4
			5

or malignant lesion. These high figures are explained by the large number of non-diseased patients included in this prospective series. The patients were clinically selected on a routine basis, i.e. without any previous screening procedure for colorectal diseases.

Also when calculating the possibility of verifying or excluding a lesion in the individual patient, high figures were obtained. Thus, the predictive value of a positive test was 92 per cent for cancer and colitis and 98 per cent for benign polypoid lesions, whereas the predictive value of a negative test was 93 per cent when assorting the non-diseased patients and 99 per cent when establishing the absence of cancer and colitis (Table 15). In other words, the chance of a positive test being incorrect was less than 8 per cent and the risk of a negative one being wrong was maximally 7 per cent.

These figures show that it is possible to disclose the afflicted patient at the DCE. On the other hand, the sensitivity of the DCE for detecting every polypoid lesion was 63 per cent and for predicting the correct type of colitis 65 per cent.

SUMMARY AND CONCLUSIONS

In this investigation the effectiveness of the DCE was studied. The investigation was based on two main series: (A) a prospective series comprising 1200 consecutive patients, dealing with bowel-cleansing regimens, and (B) a clinical prospective study on 2590 consecutive patients referred for large bowel radiography with the DCE method during a 9-month period and then followed up during a 40 to 48 month period. These patients formed the basis for the evaluation of the diagnostic efficacy of the DCE in defining the patients with and without (1) colorectal disease, (2) benign colorectal polyp, (3) malignant colorectal disease, and (4) colitis.

The findings, conclusions, and recommendations of main interest can be summarized as follows:

1. The number of patients with clinically sufficiently cleansed bowels was significantly increased by adding saline to bisacodyl, by increasing the amount of saline to Cascara-Salax, and by administering a final 2-litre tap-water enema.
2. The possibility of defining the patients with colorectal disease at the DCE was high, as was the case regarding patients without such disease.
3. The diagnostic efficacy in disclosing patients with colorectal benign polyps at the DCE was high.
4. The same was true for patients with colorectal malignant disease, as well as for those with colitis.
5. The possibility of diagnosing the correct type of chronic, non-specific colitis was 65 per cent, as was the possibility of diagnosing every polypoid lesion at the DCE.
6. To diagnose every individual polyp at the DCE, the DCE has to be repeated and double-checked. Every polyp patient should undergo colonoscopy.
7. The error at the DCE in diagnosing malignant colorectal lesions was not that of denying the existence of a lesion, but that of not predicting its true histologic nature.
8. The number of diagnosed adenomas to diagnosed adenocarcinomas was less in the rectum, sigmoid colon, and in the caecum when compared with the remainder of the colon, indicating a greater tendency of benign adenomas in these regions becoming malignant.
9. No patients with a normal DCE at the start of this series developed chronic colitis during the follow-up period, indicating the absence of prodromal radiographic signs of chronic non-specific colitis.

10. In a group of in- and out-patients referred for the DCE on a routine basis, the double-contrast examination procedure can be performed with good diagnostic results in more than 90 per cent. The failures would be due to difficulties in complying with the cleansing regimens or due to a poor general state of health in debilitated patients.
11. The DCE is well adapted for routine use and is efficient in disclosing colorectal diseases, yielding high figures of diagnostic accuracy.

REFERENCES

1. ANDRÉN L., FRIEBERG S. and WELIN S.: Roentgen diagnosis of small polyps in the colon and rectum. *Acta Radiol.* 43 (1955), 201.
2. ANDRÉN L. and FRIEBERG S.: The relation of intestinal bleeding to polyps of the colon and rectum. *Acta Chir. Scand.* 112 (1956), 47.
3. ASTE H., PUGLIESE V., GIACCHERO A., MUNIZZI F. and GENNARO M.: Is hemoccult a good test for colorectal polyps detection? *Acta Endoscopia* 10 (1980), 343.
4. AULT G.W.: The relationship between rectal polyps and rectal carcinoma. *J. Kentucky State M. A.* 50 (1952), 108.
5. BACHEM C. and GÜNTHER H.: Bariumsulfat als schattenbildendes Kontrastmittel bei Röntgenuntersuchungen. *Zschr. Röntgenkunde* 12 (1910), 369.
6. BARBI G. and FICI F.: Sperimentazione clinica controllata di un nuovo lassativo di sintesi: il picosulfato di sodio. (Note I). *Settimana Med.* 55 (1967), 987.
7. BARBI G. and FICI F.: Sperimentazione clinica controllata di un nuovo lassativo di sintesi: il picosulfato di sodio. (Note II). *Settimana Med.* 55 (1967), 997.
8. BARCLAY A.E.: Value of the X-ray in diseases of the digestive system. *Proc. R. Soc. Med.* 2 (1908/09), 53.
9. BARNES M.R.: How to get a clean colon - with less effort. *Radiology* 91 (1968), 948.
10. BARNES M.E.: Clean colons without enemas. *Am. J. Nurs.* 69 (1969), 2128.
11. BARTRAM C.I., WALMSLEY K.: A radiological and pathological correlation of the mucosal changes in ulcerative colitis. *Clin. Radiol.* 29 (1978), 323.
12. BECHER W.: Zur Anwendung des Röntgen'schen Verfahrens in der Medicin. *Dtsch. Med. Wochenschr.* 22 (1896), 202, 432.
13. BELL J.C.: General considerations in the roentgen examination of the colon. *Radiology* 55 (1950), 20.
14. BELL J.C. and DOUGLAS J.B.: Roentgen-ray diagnosis of malignant and potentially malignant lesions of the colon and rectum. *Radiology* 51 (1948), 297.

15. BERG H.H.: Röntgenuntersuchung am Innenrelief des Verdauungskanals. (2nd ed.), Thieme, Leipzig (1931).
16. BERGE T., EKELUND G., MELLNER C., PIHL B. and WENCKERT A.: Carcinoma of the colon and rectum in a defined population. Acta Chir. Scand. Suppl. No. 438 (1973).
17. BLÜHBAUM T., FRIK K. and KALKBRENNER H.: Eine neue Anwendungsart der Kolloide in der Röntgendiagnostik. Röfo 37 (1928), 18.
18. BRAHME F.: Granulomatous colitis. Roentgenologic appearance and course of the lesions. AJR 99 (1967), 35.
19. BRAHME F.: Early ulcerative colitis in children and adolescents. Dis. Colon Rectum 10 (1967), 136.
20. BRAHME F., EKELUND G.R., NORDÉN J.G. and WENCKERT A.: Metachronous colorectal polyps. A comparison between the development of colorectal polyps and carcinoma in persons with and without polyps in their history. Dis. Colon Rectum 17 (1974), 166.
21. BRAHME F. and FORK F-T.: Dynamic aspects of colonic Crohn's disease. Radiologe 15 (1975), 463.
22. BRAHME F. and FORK F-T.: Roentgenology of the colon in Crohn's disease. Air contrast studies of the lesions and their development. Radiologe 16 (1976), 489.
23. BRAHME F., LINDSTRÖM C. and WENCKERT A.: Crohn's disease in a defined population. An epidemiological study of incidence, prevalence, mortality, and secular trends in the city of Malmö, Sweden. Gastroenterology 69 (1975), 342.
24. BROWN G.R.: A new approach to colon preparation for barium enema: Preliminary report. Univ. Mich. Med. Bull. 27 (1961), 225.
25. BROWN G.R.: Preparing the colon for radiological study. Mod. Med. 38 (1970), 200.
26. BUIE L.: Polypoid disease of the colon. J. Indian Med. Assoc. 30 (1937), 622.
27. BUNTAIN W.L., REMINE W.H. and FARROW G.M.: Premalignancy of polyps of the colon. Surg. Gynecol. Obstet. 134 (1972), 499.
28. CANNON W.B.: The movements of the intestines studied by means of the Röntgen rays. J. M. Res. 7 (1902), 72.

29. CASE J.T.: X-ray observations on colonic peristalsis and anti-peristalsis. The XVII'th Intern. Congr. Med., London (1913), Med. Rec. 85 (1914), 415.
30. CASE J.T.: Stereoroentgenography: The alimentary tract. Southworth Co., Troy, N.Y. (1914).
31. CASE J.T.: Fifty years of roentgen rays in gastroenterology. AJR 54 (1945), 607.
32. CHASSARD, LAPINÉ: Étude radiographique de l'arcade pubienne chez la femme enceinte: une nouvelle méthode d'appréciation du diamètre bi-ischiatique. J. de Radiol. et d'Electrol 7 (1923), 113.
33. CHRISTIE A.C., COE F.O., HAMPTON A.O. and WYATT G.M.: The value of tannic acid enema and post-evacuation roentgenograms in examination of the colon. AJR 63 (1950), 657.
34. CHRISTIE J.P.: Fiberoptic colonoscopy: Diagnostic value in 250 consecutive patients. South. Med. J. 69 (1976), 540.
35. COLE L.G. and EINHORN M.: Radiograms of the digestive tract by inflation with air N.Y. Med. J. 92 (1910), 705.
36. COLE collaborators: Roentgenologic exploration of the mucosa of the gastro-intestinal tract. Radiology 18 (1932), 221.
37. COLE collaborators: Important anatomical data of the digestive tract. Radiology 18 (1932), 471.
38. COLE collaborators: Findings observed in the gastro-intestinal tract. Radiology 18 (1932), 886.
39. COOLEY R.N., AGNEW C.H. and RIOS G.: Diagnostic accuracy of the barium enema study in carcinoma of the colon and rectum. AJR 84 (1960), 316.
40. CORREA P., DUQUE E., CUELLO C. and HAENSZEL W.: Polyps of the colon and rectum in Cali, Colombia. Int. J. Cancer 9 (1972), 86.
41. DeBEER R.A., GEFFIN A., OZOKTAY S., SHINYA H. and WOLFF W.I.: Comparison of colonoscopy and contrast x-ray study in diagnosis of 500 cases of colorectal disease. J. Amer. Osteopathic Ass. 75 (1976), 569.
42. DeCARVALHO A., MADSEN B.: Prevention of crackle in double contrast examinations of the colon. Acta Radiol. (Diagn) 22 (1981), 63.

43. de LACEY G.: The double contrast barium enema. In: X-Ray Focus, Ilford 15 (1977), 59.
44. DePEYSTER F.A. and GILCHRIST R.K.: Symposium on function and disease of anorectum and colon: pathology of cancer of colon and rectum: classification and models of spread. Surg. Clin. North Am. 35 (1955), 1295.
45. DODD G.D.: The radiologic diagnosis of carcinoma of the colon. In: Gastro-intestinal Cancer. Ed: Stroehlein J.R. and Romsdahl M.M., Raven Press, New York (1981), 327.
46. DOUGLAS J.B.: The double-contrast examination of the colon. Radiology 60 (1953), 490.
47. DUKES C.: Simple tumours of the large intestine and their relation to cancer. Br. J. Surg. 13 (1925), 720.
48. DUKES C.E.: The classification of cancer of the rectum. J. Path. Bact. 35 (1932), 323.
49. DUKES C.E.: Pre-cancerous condition of the colon and rectum. J. R. Coll. Surg. Edinb. 3 (1958), 182.
50. EKELUND G.: On cancer and polyps of colon and rectum. Acta Pathol. Microbiol. Scand. Suppl. No. 59 (1963), 165.
51. EKELUND G.: On colorectal polyps and carcinoma with special reference to their interrelationship. Thesis, Lund (1974).
52. EKELUND G.R.: Cancer risk with single and multiple adenomas: Synchronous and metachronous tumours. In: Colorectal Cancer: Prevention, Epidemiology, and Screening. Ed: Winawer S., Schottenfield D. and Sherlock P., Raven Press, New York (1980).
53. EKELUND G., LINDSTRÖM C. and ROSENGREN J-E.: Appearance and growth of early carcinomas of the colon-rectum. Acta Radiol. 15 (1974), 670.
54. EMBRING G. and MATTSSON O.: Barium contrast agents. Acta Radiol. 7 (1968), 245.
55. ENGQUIST I.F.: The incidence and significance of polyps of the colon and rectum. Surgery 42 (1957), 681.
56. ENGQUIST I.F. and STATE D.: Rectal and colonic polyps. Surgery 32 (1952), 696.
57. ENTERLINE H.T., EVANS G.W., MERCADO-LUGO R., MILLER L. and FITTS W.T.: Malignant potential of adenomas of colon and rectum. JAMA 179 (1962), 322.

58. ETTINGER A. and ELKIN M.: Study of the sigmoid by special roentgenographic views. *AJR* 72 (1954), 199.
59. EVANGELISTI G.B. and FARINA O.: La stipsi cronica abituale (e suo trattamento con il sale bisodico dell'acido 4, 4' - (2-picoliliden)-bis-fenilsol-forico). *La Clinica* 27 (1967), 182.
60. FALTERMAN K.W., HILL C.B., MARKEY J.C., FOX J.W. and COHN J.: Cancer of the colon, rectum and anus: A review of 2313 cases. *Cancer* 34 (1974), 951.
61. FENOGLIO C.M., KAYE G.I. and LANE N.: Distribution of human colonic lymphatics in normal, hyperplastic and adenomatous tissue. Its relationship to metastasis from small carcinomas in pedunculated adenomas with two case reports. *Gastroenterology* 64 (1973), 51.
62. FIGIEL L.S., FIGIEL S.J. and HENNESSEY A.: Carcinoma of the colon. Incidence of error in the roentgen diagnosis. *Am. J. Gastroenterol.* 40 (1963), 487.
63. FIGIEL S.J., FIGIEL L.S. and RUSH D.K.: Study of colon by use of high-kilovoltage spot-compression technique. *JAMA* 166 (1958), 1269.
64. FISCHER A.W.: "Über eine neue röntgenologische Untersuchungsmethode des Dickdarms: Kombination von Kontrasteinlauf und Luftaufblähung. *Klin. Wochenschr.* 2 (1923), 1595.
65. FISCHER A.W.: "Über die Röntgenuntersuchung des Dickdarmes mit Hilfe einer Kombination von Lufteinblasung und Kontrasteinlauf. *Arch. Klin. Chir.* 134 (1925), 209.
66. FISCHER A.W.: Zur röntgenologischen Diagnose und Differentialdiagnose der Polyposis coli. *Röfo* 430 (1926), 716.
67. FITTS W.T.: Adenomas of the colon and rectum. Their malignant potential. *Am. J. Surg.* 101 (1961), 87.
68. FITZGIBBON G. and RANKIN F.W.: Polyps of the large intestine. *Surg. Gynecol. Obstet.* 52 (1931), 1136.
69. FORK F-T.: Resultatvergleich zwischen der Doppelkontrastuntersuchung des Dickdarmes und der Koloskopie mit Biopsie. In: *Die Doppelkontrastuntersuchung des Dickdarms. Erfahrungen mit der Welin-Methode.* Ed. Welin S. and Welin G. Thieme Verlag, Stuttgart (1980).

70. FORK F-T.: Double contrast enema and colonoscopy in polyp detection. Gut 22 (1981), 971.
71. FORK F-T., EKBERG O., NILSSON G., RERUP C. and SKINHØJ A.: Colon cleansing regimens. A clinical study in 1200 patients. Gastrointest. Radiol. 7 (1982), 1.
72. FORK F-T. and ROSENGREN J-E.: Bubbelreduktion vid röntgen med dubbelkontrast. (In Swedish). Läkartidningen 45 (1982), 4018.
73. FORSELL G.: Normale und pathologische Reliefbilder der Schleimhaut. Ein Überblick über die Autoplastik des Digestionskanales. Verhandl. Gesellsch. Verd. Stoffwechselkrankh. 7 (1927), 199.
74. FRANKLIN R. and McSWAIN B.: Carcinoma of the colon, rectum and anus. Ann. Surg. 171 (1970), 811.
75. FRIEDLAND G.W. and POOLE G.J.: False-positive "eccentric target sign" on barium-air contrast enema examination. Report of a case. Radiology 99 (1971), 67.
76. FRÜMÖRGEN P. and DEMLING L.: Complications of diagnostic and therapeutic colonoscopy in the Federal Republic of Germany. Results of an inquiry. Endoscopy 2 (1979), 146.
77. FUCHS H.F., STADLER U. and REICHERT J.: Der Stellenwert der Röntgendiagnostik bei der Frühdiagnose des Colonicarcinoms im Vergleich zur Koloskopie. Radiologe 19 (1979), 21.
78. GABRIELSSON N., GRANQVIST S., OHLSEN H. and SUNDELIN P.: Malignancy of colonic polyps. Diagnosis and management. Acta Radiol. Diagn. 19 (1978), 479.
79. GALEN R.S. and GAMBINO S.R.: Beyond normality: The predictive value and efficiency of medical diagnoses. John Wiley & Sons, New York (1975).
80. GARLAND L.H.: Discussion. Radiology 55 (1950), 22.
81. GELFAND D.W.: High density, low viscosity barium for fine mucosal detail on double-contrast upper gastrointestinal examinations. AJR 130 (1978), 831.
82. GELFAND D.W. and OTT D.J.: Single- vs. double-contrast gastrointestinal studies: Critical analysis of reported statistics. AJR 137 (1981), 523.
83. GERSHON-COHEN J. and SHAY H.: Colon as studied by double contrast enema. AJR 27 (1932), 836.

84. GIANTURCO C.: The comparative value of various methods in the roentgenologic examination of the colon. *Illinois Med. J.* 71 (1937), 67.
85. GIANTURCO C.: High-voltage technic in the diagnosis of polypoid growths of the colon. *Radiology* 55 (1950), 27.
86. GIANTURCO C. and MILLER G.A.: Routine search for colonic polyps by high-voltage radiography. *Radiology* 60 (1953), 496.
87. GILBERTSEN V.A.: Proctosigmoidoscopy and polypectomy in reducing the incidence of rectal cancer. *Cancer* 34 (1974), 936.
88. GILLESPIE P.E., CHAMBERS T.J., CHAN K.W., DORONZO F., MORSON B.C. and WILLIAMS C.B.: Colonic adenomas - a colonoscopy survey. *Gut* 20 (1979), 240.
89. GOLDBERG H.I. and JEFFREY R.B.: Recent advances in the radiographic evaluation of inflammatory bowel disease. *Med.Clin. North Am.* 64 (1980), 1059.
90. von GOURWITSCH G.: Über das Kartoffelmehldekot als Vehikel für kontrastbildende Mittel in der Röntgenuntersuchung des Verdauungskanal. *Röfo* 19 (1912), 214.
91. GREGOR D.H.: Occult blood testing for detection of asymptomatic colon cancer. *Cancer* 28 (1971), 131.
92. GRINNELL R.S. and LANE N.: Benign and malignant adenomatous polyps and papillary adenomas of the colon and rectum. An analysis of 1,856 tumors in 1,335 patients. *Int. Abstr. Surg.* 106 (1958), 519.
93. GROEDEL F.M.: In: *Grundriss und Atlas der Röntgendiagnostik in der inneren Medizin.* Ed: Lehman J.F., München (1909).
94. HAENISCH G.F.: Die Röntgenuntersuchung bei Verengungen des Dickdarms. *Röntgenologische Frühdiagnose des Dickdarmskarzinoms.* Münch. Med. Wochenschr. 58 (1911), 2375.
95. HAENISCH G.F.: The roentgen examination of the large intestine. *Arch. Roentgen Ray* 17 (1912), 208.
96. HAMELIN L. and HURTUBISE M.: Remote control technique in double contrast study of the colon. *AJR* 119 (1973), 382.
97. HAMILTON J.B.: The use of tannic acid in barium enemas. *AJR* 56 (1946), 101.
98. HELWIG F.C.: The association of benign and malignant polyps of the large intestine. *Dis. Colon Rectum* 3 (1960), 343.

99. HERTZ R.E.L., DEDDISH M.R. and DAY E.: Value of periodic examinations in detecting cancer of the rectum and colon. Postgrad. Med. 27 (1960), 290.
100. HETTLER M.: Zur Technik der Doppelkontrastdarstellung des Dickdarms. Radiologe 2 (1962), 115.
101. HEWITT J., RIGBY J., REEVE J. and COX A.G.: Whole-gut irrigation in preparation for large-bowel surgery. Lancet II (1973), 337.
102. HILDEBRAND H.: "Über den diagnostischen Wert der Röntgenstrahlen in der inneren Medizin. Münch. Med. Wochenschr. 48 (1901), 2008.
103. HILDELL J.: Radiographic patterns of Crohn's disease. A long term study of pre- and postoperative findings in 195 patients, with special reference to recurrence of the disease, Thesis, Malmö (1978).
104. HOGAN W.J., HENSLEY G.T. and GEENEN J.E.: Endoscopic evaluation of inflammatory bowel disease. Med. Clin. North Am. 64 (1980), 1083.
105. HOLZKNECHT G.: Der normale Magen nach Form, Lage und Grösse. Mitteilungen Allg. Krankenh. Wien 1 (1906), 72.
106. HULST H.: Roentgenography in diseases of stomach and intestine. Trans Am. Roentgen Ray Soc. (1906), 40.
107. JAMES W.B.: Double contrast radiology in the gastrointestinal tract. Clin. in Gastroenterol. 7 (1978), 397.
108. JAUCH R., HANKWITZ R., BESCHKE K. and PELZER H.: Bis-(p-hydroxyphenyl)-pyridyl-2-methane: The common laxative principle of Bisacodyl and sodium picosulfate. Arzneim Forsch. 25 (1975), 1796.
109. JACKSON B.R.: Adenomas of the colon and rectum: Histopathology and management. Dis. Colon Rectum 17 (1974), 656.
110. JOLLASSE: "Über die mit der Röntgenuntersuchung des Magen-Darmkanals erzielten Resultate in anatomischer, physiologischer und pathologischer Beziehung. Röfo 16 (1910/11), 26.
111. JONES H.H., KAPLAN H.S. and WINDHOLZ F.: Air-contrast colon examination with colloidal barium. Radiology 56 (1951), 561.
112. KALKBRENNER H.: "Über eine neue röntgenologische Untersuchungsmethode des Dickdarmes: die Darstellung des Schleimhautreliefs mit Umbrathor. Röfo 38 (1928), 325.

113. KALUS M.: Carcinoma and adenomatous polyps of the colon and rectum in biopsy and organ tissue culture. *Cancer* 30 (1972), 972.
114. KELVIN F.M., ODDSON T.A., RICE R.P., GARBUTT J.T. and BRADEN-HAM B.P.: Double contrast barium enema in Crohn's disease and ulcerative colitis. *AJR* 131 (1978), 207.
115. KELVIN F.M. and GEDGAUDAS R.K.: Radiologic diagnosis of Crohn's disease (with emphasis on its early manifestations). *CRC Crit. Rev. Diagn. Imaging* 16 (1981), 43.
116. KIRSNER J.B. and SHORTER R.G.: Recent developments in "non-specific" inflammatory bowel diseases. *N. Engl. J. Med.* 306 (1982), 775, 837.
117. KNOTHE W.: Röntgenstudien am Schleimhautrelief des normalen und kranken Dickdarms. *Röfo* 36 (1927), 55.
118. KRAUSE P. and SCHILLING: Die röntgenologischen Untersuchungsmethoden zur Darstellung des Magendarmkanales mit besonderer Berücksichtigung der Kontrastmittel. *Röfo* 20 (1913), 455.
119. LANCET: Polyps, enemas and colonoscopes. Ed. June 1974, 1265.
120. LANE N. and FENOGLIO C.M.: The adenoma-carcinoma sequence in the stomach and colon. *Gastrointest. Radiol.* 1 (1976), 111.
121. LANE N. and LEV R.: Observations on the origin of adenomatous epithelium of the colon. Serial section studies of minute polyps in familial polyposis. *Cancer* 16 (1963), 751.
122. LANE N., KAPLAN H. and PASCAL R.R.: Minute adenomatous and hyperplastic polyps of the colon: Divergent patterns of epithelial growth with specific associated mesenchymal changes. *Gastroenterology* 60 (1971), 537.
123. LAUER J.D., CARLSON H.C. and WOLLAEGER E.E.: Accuracy of roentgenologic examination in detecting carcinoma of the colon. *Dis. Colon Rectum* 8 (1965), 190.
124. LAUFER I.: The double-contrast enema: Myths and misconceptions. *Gastrointest. Radiol.* 1 (1976), 19.
125. LAUFER I.: Air contrast studies of the colon in inflammatory bowel disease. *CRC Crit. Rev. Diagn. Imaging* 12 (1977), 421.
126. LAUFER I. and HAMILTON J.: The radiological differentiation between ulcerative and granulomatous colitis by double contrast radiology. *Am. J. Gastroenterol.* 66 (1976), 259.

127. LAUFER I., MULLENS J.E. and HAMILTON J.: Correlation of endoscopy and double contrast radiography in the early stages of ulcerative and granulomatous colitis. *Radiology* 118 (1976), 1.
128. LAUFER I., SMITH N.C.W. and MULLENS J.E.: The radiological demonstration of colorectal polyps undetected by endoscopy. *Gastroenterology* 70 (1976), 167.
129. LAURELL H.: Discussion. *Acta Radiol. Diagn.* 1 (1922), 491.
130. LEDOUX-LEBARD R. and GARCIA-CALDERON J.: Les techniques d'examen de la muqueuse du gros intestin. *J. Radiol. Electrol.* 17 (1933), 429.
131. LEINICKE J.L., DODDS W.J., HOGAN W.J. and STEWART E.T.: A comparison of colonoscopy and roentgenography for detecting polypoid lesions of the colon. *Gastrointest. Radiol.* 2 (1977), 125.
132. LINDHAGEN T.: Crohn's disease in a defined population. Results of surgical treatment. Thesis, Lund, Malmö (1982).
133. LINDSTRÖM C.G., ROSENGREN J.E. and EKBERG O.: Experimental colonic tumours in the rat. III. Induction time, distribution and appearance of induced tumours. *Acta Radiol. Diagn.* 19 (1978), 799.
134. LOCKHART-MUMMERY H. and MORSON B.: Crohn's disease (regional enteritis) of the large intestine and its distinction from ulcerative colitis. *Gut* 1 (1960), 87.
135. LOCKHART-MUMMERY H.E. and MORSON B.C.: Crohn's disease of the large intestine. *Gut* 5 (1964), 493.
136. LOOSE H.W.C. and WILLIAMS C.B.: Barium enema versus colonoscopy. *Proc. R. Soc. Med.* 67 (1974), 1033.
137. LUSTED L.B.: Decision-making studies in patient management. *N. Engl. J. Med* 8 (1971), 416.
138. MARGULIS A.R., GOLDBERG H.I., LAWSON T.L., MONTGOMERY C.K., RAMBO O.N., NOONAN C.D. and AMBERG J.R.: The overlapping spectrum of ulcerative and granulomatous colitis: A roentgenographic-pathologic study. *AJR* 113 (1971), 325.
139. MARSHAK R.H. and LINDNER A.E.: Granulomatous colitis. *Semin. Roentgenol.* 3 (1968), 27.
140. MARSHAK R.H., LINDNER A.E. and MAKLANSKY D.: Radiology of the colon. Monograph. W.B. Saunders, Philadelphia (1980).

141. MENDELOFF A.I., LaMONT J.T. and ISSELBACHER K.J.: Diseases of the colon and rectum. In: Harrison's Principles of Internal Medicine. 7th ed. Eds: Wintrobe M.W., Braunwald E., Isselbacher K.J. and Petersdorf R.G., (1974), 1495.
142. MILLER R.E. and BRAHME F.: The clarity of good technic. Am. J. Dig. Dis. 12 (1967), 418.
143. MILLER R.E. and LEHMAN G.: Polypoid colonic lesions undetected by endoscopy. Radiology 129 (1978), 295.
144. MORETON R.D.: Double-contrast examination of the colon with special emphasis on studies of the sigmoid. Radiology 60 (1953), 510.
145. MORETON R.D., COOPER E.M. and FOEGELLE E.F.: A simple one-stage method of double-contrast study of the colon. Radiology 56 (1951), 214.
146. MORETON R.D. and YATES C.W.: Roentgenologic study of the colon. Value of the double contrast enema. Texas State J. Med. 45 (1949), 157.
147. MORSON B.C.: Evolution of cancer of the colon and rectum. Cancer 34 (1974), 845.
148. MORSON B.C.: The polyp-cancer sequence in the large bowel. Proc. R. Soc. Med. 67 (1974), 451.
149. MORSON B.C.: Genesis of colorectal cancer. Clin. Gastroenterol. 5 (1976), 505.
150. MORSON B.C. and DAWSON M.P.: Gastrointestinal pathology. 2nd ed. Blackwell Scientific Publications, Oxford, London, Edinburgh, Melbourne (1979).
151. MUTO T., KAMIYA J., SAWADA T., KUSAMA S., ITAI Y., IKENAGA T., YAMASHIRO M., HINO Y. and YAMAGUCHI S.: Colonoscopic polypectomy in diagnosis and treatment of early carcinoma of the large intestine. Dis. Colon Rectum 23 (1980), 68.
152. MYREN J., EIE H. and SERCK-HANSEN A.: The diagnosis of colitis by colonoscopy with biopsy and X-ray examination. A blind comparative study. Scand. J. Gastroenterol. 11 (1976), 141.
153. ORTMAYER M.: Carcinoma in small polyps of the distal colon: A sigmoidoscopic and histologic study. Gastroenterology 31 (1956), 404.

154. OTT D.J. and GELFAND D.W.: Colorectal tumours: Pathology and detection. *AJR* 131 (1978), 691.
155. OTT D.J., GELFAND D.W. and RAMQUIST N.A.: Causes of error in gastrointestinal radiology. II. Barium enema examination. *Gastrointest. Radiol.* 5 (1980), 99.
156. OTT D.J., GELFAND D.W., WU W.C. and KERR R.M.: Sensitivity of double-contrast barium enema: Emphasis on polyp detection. *AJR* 135 (1980), 327.
157. OVERHOLT B.F.: Progress in gastroenterology. Colonoscopy. A review. *Gastroenterology* 68 (1975), 1308.
158. PANSDORF H.: Die Röntgendiagnostik der entzündlichen Dickdarmerkrankungen und ihre Abgrenzung gegenüber dem Carcinom. *Röntgenpraxis* 2 (1930), 732.
159. PANTONE A.M. and BERLIN L.: Air-contrast examination of the colon: An entity of the past. *Am. J. Dig. Dis.* 12 (1967), 110.
160. PERL T. and GOLDMAN W.: Unraveling tangled sigmoid: Routine angulation of tube in detection of occult lesions. *AJR* 110 (1970), 399.
161. PFAHLER G.E.: Diagnosis of size, form, position and motility of the stomach and bowel by means of the X-ray. *Tr. Coll. Physicians* 27 (1905), 79.
162. PFAHLER G.E.: Physiologic and clinical observations on the alimentary canal by means of the roentgenrays. *JAMA* 49 (1907), 2069.
163. POLGAR F.: Contrast enema in lateral recumbency: Aided gas filling of the colon. *Radiology* 53 (1949), 49.
164. PRICE A.B. and MORSON B.C.: Inflammatory bowel disease. The surgical pathology of Crohn's disease and ulcerative colitis. *Hum. Pathol.* 6 (1975), 7.
165. RIEDER H.: Radiologische Untersuchungen des Magens und Darmes beim lebenden Menschen. *Münch. Med. Wochenschr.* 51 (1904), 1548.
166. RIGLER L.G. and ERICKSEN L.G.: Benign tumors of the stomach. Observations on their incidence and malignant degeneration. *Radiology* 26 (1936), 6.
167. ROBINSON J.M.: Detection of small lesions of the large bowel: Barium enema versus double contrast. *Calif. Med.* 81 (1954), 321.

168. ROOT J.C. and GREENWALD C.M.: Double contrast study of colon: Routine lateral recumbent view. *Radiology* 63 (1954), 241.
169. ROSENGREN J.E.: Radiographic investigation of experimental induced colonic tumors in the rat. An in vivo examination including anatomic, histopathologic and immunologic studies. Thesis, Lund, Malmö (1977).
170. ROSENGREN J.E. and ÅBERG C.: Cleansing of the colon without enemas. *Radiologe* 15 (1975), 421.
171. ROSENSWEIG J. and HORWITZ A.: Adenomatous tumours of the colon and rectum: The importance of early detection and treatment. *Am. Surg.* 24 (1958), 515.
172. ROTH J.L.A.: Diagnosis and differential diagnosis of chronic ulcerative colitis and Crohn's colitis. In: *Inflammatory Bowel Disease*. Ed.: Kirsner J.B. and Shorter R.G., Lea and Febiger, Philadelphia (1980), 166.
173. ROUX J.C. and BALTHAZARD V.: Sur l'emploi des rayons Röntgen pour l'étude de la motricité stomacale. *Compt. rend. Soc. de biol.* 49 (1897), 567.
174. RÖNTGEN W.C.: Eine neue Art von Strahlen. *Sitzgsber. Physik. Med. Ges. Würzburg* 137 (1895), 132.
175. SAUNDERS C.G. and MacEVEN D.W.: Delay in diagnosis of colonic cancer - a continuing challenge. *Radiology* 101 (1971), 207.
176. SCHACHTER H., GOLDSTEIN M.J., RAPPAPORT H., FENNESSEY J.J., and KIRSNER J.R.: Ulcerative and "granulomatous" colitis - validity of differential diagnostic criteria: study of 100 patients treated by total colectomy. *Ann. Intern. Med.* 72 (1970), 841.
177. SCHENEK E.: Über die Darstellung von Dickdarmstenose durch das Röntgenverfahren. *Röfo* 12 (1908), 323.
178. SCHILLING T.: Die Doppelkontrasttechnik in der Dickdarm-Diagnostik. *Röntgenblätter* 30 (1977), 388.
179. SCHÜLE A.: Über die Sondierung und Radiographie des Dickdarms. *Arch. Verdauungskrankh.* 10 (1904), 111.
180. SCHÜRGER R.: Die Routinelaxation und eine sachgemäße individuelle Behandlung der Obstipation. *Therapiewoche* 22 (1972), 1873.
181. SCHWARZ G.: *Klinische Röntgendiagnostik des Dickdarms und ihre physiologischen Grundlagen*. Springer, Berlin (1914).

182. SHAY H. and GERSHON-COHEN J.: Diagnostic value of double contrast enema, with special reference to diagnosis of early neoplastic lesions of colon. *Surg. Gynecol. Obstet.* 58 (1934), 52.
183. SHINYA H., WOLFF W., DeBEER R. and GEFFEN A.: Radiographic and colonoscopic diagnosis of colon and rectal pathology - an adjunctive and comparative analysis of five-hundred cases. *Gastroenterology* 66 (1974), 825.
184. SIMPKINS K.C. and STEVENSON G.W.: The modified Malmö double-contrast barium enema in colitis: An assessment of its accuracy in reflecting sigmoidoscopic findings. *Br. J. Radiol.* 45 (1972), 486.
185. SIMPKINS K.C. and YOUNG A.C.: The radiology of colonic and rectal polyps. *Br. J. Surg.* 55 (1968), 731.
186. SPRATT J.S. and ACKERMAN L.V.: Small primary adenocarcinomas of the colon and rectum. *JAMA* 179 (1962), 337.
187. SPRATT J.S., ACKERMAN L.V. and MOYER C.A.: Relationship of polyps of the colon to colonic cancer. *Ann. Surg.* 148 (1958), 682.
188. STEIN H. and KRATZER G.L.: Removal of polyps of the colon by laparotomy compared with removal by colonoscopy. *Dis. Colon Rectum* 18 (1975), 397.
189. STEVENSON C.A.: Technics of double contrast examination of colon. *Surg. Clin. North Am.* 32 (1952), 1531.
190. STEVENSON C.A.: The development of the colon examination. *AJR* 71 (1954), 385.
191. STEVENSON C.A. and WILSON M.: Indications for the double contrast colon examination. *AJR* 71 (1954), 398.
192. STRAUSS: Beitrag zur Würdigung der diagnostischen Bedeutung der Röntgendurchleuchtung. *Dtsch. Med. Wochenschr.* 22 (1896), 161.
193. SWENSON P.C. and WIGH R.: The role of the roentgenologist in the diagnosis of polypoid disease of the colon. *AJR* 59 (1948), 108.
194. SWINTON N.W. and HAUG A.D.: The frequency of precancerous lesions in the rectum and colon. *Lahey Clin. Bull* 5 (1947), 84.
195. SWINTON N.W. and WARREN S.: Polyps of the colon and rectum and their relation to malignancy. *JAMA* 113 (1939), 1927.

196. THOENI R.F. and MARGULIS A.R.: Radiology in inflammatory disease of the colon: An area of increased interest for the modern clinician. *Invest. Radiol.* 15 (1980), 281.
197. THOENI R.F. and MENUCK L.: Comparison of barium enema and colonoscopy in the detection of small colonic polyps. *Radiology* 124 (1977), 631.
198. WAYE J.D.: Endoscopy in inflammatory bowel disease. *Clin. Gastroenterol.* 9 (1980), 279.
199. WAYE J.D. and BRAUNFELD S.: Surveillance intervals after colonoscopic polypectomy. *Endoscopy* 14 (1982), 79.
200. WEBER H.M.: Roentgenologic demonstration of polypoid lesions and polyposis of large intestine. *AJR* 25 (1931), 577.
201. WEBER H.M.: Carcinoma of the colon: Its roentgenologic manifestations and differential diagnosis. *Am. J. Cancer* 17 (1933), 321.
202. WEBER H.M.: Roentgen diagnosis of diseases of the colon. An evaluation of methods. *AJR* 31 (1934), 607.
203. WELIN S.: Modern trends in diagnostic roentgenology of the colon. *Br. J. Radiol.* 31 (1958), 453.
204. WELIN S.: "Über moderne röntgenologische Dickdarmdiagnostik unter besonderer Berücksichtigung der Doppelkontrastmethode. *Münch. Med. Wochenschr.* 100 (1958), 1142.
205. WELIN S.: "Über die röntgenologische Untersuchung des Dickdarmes mit der Doppelkontrastmethode. Die Malmömodifikation. *Radiologe* 2 (1962), 87.
206. WELIN S.: Results of the Malmö technique of colon examinations. *JAMA* 199 (1967), 119.
207. WELIN S.: Polyps in colon-rectum and cancer. Radiological diagnosis. In: *Thule Intern. Symposium, Cancer and Ageing, Stockholm* (1968), 253.
208. WELIN S.: The radiological detection of early carcinoma and premalignant lesions of the colon and rectum. *J. R. Coll. Surg. Edinb.* 14 (1969), 278.
209. WELIN S. and BRAHME F.: The double contrast method in ulcerative colitis. *Acta Radiol.* 55 (1961), 257.
210. WELIN S. and LÖRINC P.: Das Röntgenbild des villösen (zottenförmigen) Tumors im Bereich des Colons. *Radiologe* 2 (1962), 107.

211. WENER L.: The angle prone projection: Its value in diagnosis of low-lying lesions. *AJR* 110 (1970), 393.
212. WHITEHEAD R.: Pathology of Crohn's disease. In: *Inflammatory Bowel Disease*. Ed.: Kirsner J.B. and Shorter R.G., Lea and Febiger, Philadelphia (1980), 296.
213. WILLIAMS C.: Evaluation of the colonoscopic examination: Results of three studies. *Dis. Colon Rectum* 18 (1975), 366.
214. WILLIAMS C.B., HUNT R.H., LOOSE H., RIDDELL R.H., SAKAI Y., and SWARBRICK E.T.: Colonoscopy in the management of colon polyps. *Br. J. Sur.* 61 (1974), 673.
215. WILLIAMS C.B., MACRAE F.A. and BARTRAM C.I.: A prospective study of diagnostic methods in adenoma follow-up. *Endoscopy* 14 (1982), 74.
216. WILLIAMS F.H.: In: *The roentgen rays in medicine and surgery as an aid in diagnosis and as a therapeutic agent*. McMillan Co., New York (1901).
217. WILLIAMS H.J., STEPHENS D.H., and CARLSON H.C.: Double-contrast radiography: Colonic inflammatory Disease. *AJR* 137 (1981), 315.
218. WILSON G.S., DALE E.H. and BRINES O.A.: An evaluation of polyps detected in 20,847 routine sigmoidoscopic examinations. *Am. J. Surg.* 90 (1955), 834.
219. WINAWER S.J., MILLER D.G., SCHOTTENFELD D., LEIDNER S.D., SHERLOCK P., BEFLER B. and STEARNS M.W.: Feasibility of fecal occult-blood testing for detection of colorectal neoplasia. *Cancer* 40 (1977), 2616.
220. WINAWER S.J., POLESKI M.H. and SHERLOCK P.: Susceptibility to colorectal cancer: Current concepts of screening, diagnosis and risk. In: *Developments in Digestive Diseases*, No. 2. Ed.: Berk J.E., Lea and Febiger, Philadelphia (1979).
221. VIRKKUNEN P. and RETULAINEN M.: A new method for studying barium sulphate contrast media in vitro. Some factors contributing to the visualization of area gastricae. *Br. J. Radiol.* 53 (1980), 765.
222. WOLFF W.I. and SHINYA H.: A new approach to colonic polyps. *Ann. Surg.* 178 (1973), 367.

223. WOLFF W.I. and SHINYA H.: Colonofiberscopic management of colonic polyps. Dis. Colon Rectum 16 (1973), 87.
224. WOLFF W.I. and SHINYA H.: Endoscopic polypectomy. Therapeutic and clinicopathologic aspects. Cancer 36 (1975), 683.
225. WOLFF W.I., SHIHYA H., GEFFEN A., OZOKTAY S. and DeBEER R.: Comparison of colonoscopy and the contrast enema in five hundred patients with colorectal disease. Ann. J. Surg. 129 (1975), 181.
226. YERUSHALMY J.: The statistical assessment of the variability in observer perception and description of roentgenographic pulmonary shadows. Radiol. Clin. North Am. 7 (1969), 381.
227. YOUNG B.R. and SCANLON R.L.: Roentgen demonstration and significance of the pedicle in polypoid tumors of the alimentary tract. AJR 68 (1952), 894.

From the Department of Diagnostic Radiology^{1/}, Malmö General Hospital,
Ferring Pharmaceuticals^{2/}, Malmö, Department of Pharmacology^{3/}, University
of Lund, Lund, Sweden, and Ercopharm^{4/}, Vedbaek, Denmark

COLON CLEANSING REGIMENS

A clinical study in 1200 patients

FRANS-THOMAS FORK^{1/}, OLLE EKBERG^{1/}, GÖRAN NILSSON^{2/}, CLAES RERUP^{3/}
and ANNETTE SKINHØJ^{4/}

Abstract. The purgative effect of bisacodyl, anthraquinone glycosides (Cascara), and sodium picosulfate, alone or in combination with a saline purge and a tap water enema, was studied in 1200 patients. The cleansing effect was scored with regard to retained fecal residue evident on double-contrast studies of the colon.

The combination of a contact laxative and a saline purge produced good cleansing effect in 52%-80% of the patients. With an additional tap water enema given 1 hour before the colon examination, however, 96% of the colons were clean.

The taste and the effects of the cleansing systems were tolerated favorably by more than 90% of the patients. However, 17% reported restriction in work capacity on the day of bowel cleansing.

Key words: Barium double-contrast enema - Colon, radiography - Colon, effects of drugs.

Introduction

During the recent decade, a colon cleansing regimen consisting of a combination of overhydration, low bulk diet, saline purge, and a contact laxative (Cascara-Salax) given orally was used in our department as a routine bowel preparation. Its safety, efficacy, and reproducibility was also tested by cleansing degree varying from 54% (inpatients) to 78% (outpatients) /1-2/. Other studies have shown clean colon in 85%-95% of patients receiving a similar preparation with bisacodyl as laxative /3,4/.

In routine work, we experienced failure to complete the regimen of Cascara-Salax (2 pills of Cascara-Sagrada, each equal to 30 mg of anthraquinone glycoside and 7.5 g of magnesium sulfate, morning and afternoon) in up to 10% of our outpatients /1/. In an effort to increase the proportion of clean bowels, we studied various compositions of sodium picosulfate and magnesium citrate (For practical reasons magnesium oxide and citric acid were dispensed separately, yield-

ing a solution equivalent to magnesium citrate). This pharmaceutical composition offers simple administration (powder easily dissolved in water) and the advantage of one type of application. Its effect was compared with that of the saline purge and derivatives of anthraquinone with magnesium sulfate and bisacodyl with and without magnesium citrate /5/. The addition of a final tap water enema was also investigated.

Pharmacological Background

Salts of 2 and 3 basic acids (sulfates, hydroxides, citrates, etc.) are slowly absorbed in the small gut. They stimulate intestinal peristalsis by osmotic retention of water in the bulk /6/ and by a more complex action indicated by release of cholecystokinin /6-9/. Only if absorbed in significant amounts by patients with reduced kidney function is the magnesium ion toxic; otherwise it is harmless /10/.

The active components of Cascara are anthraquinone glycosides. Following activation by enzymes, they act through a reduction of antiperistalsis in the right colon, and by an increase in the peristaltic propulsion via stimulation of Auerbach's plexus in the colon wall /6, 11-13/. Change in permeability of the colonic mucosa with ensuing water and electrolyte retention occurs /8/, but adverse effects are few /1, 6, 14, 15/.

Bisacodyl and sodium picosulfate are potent members of a series of phenol-ester compounds with laxative properties /4, 16, 17/. They are low-toxic substances referred to as contact laxatives, i.e. mucosal or submucosal application gives about 8-fold stronger response than subcutaneous administration /6, 18 to 20/. Their neuromuscular effect is eliminated by preceding anesthesia of the mucosa /21/.

The same hydrolysis product, desacetylbisacodyl, is responsible for the effect of bisacodyl and sodium picosulfate /22-24/, but it is formed by esterases of different origin. Ten percent of the substances are excreted in the urine as a glucuronoid of the free phenol /24/. The laxative effect is mediated by in-

hibition of intestinal water absorption /23, 25/, by increased passage of water from the intestinal mucosa to the lumen, and stimulation of the parasympathetic system of the colon /21/.

Bisacodyl is transformed to the active form in the stomach and the intestines by endogenous esterases. It is insoluble in water /22/. A high cleansing score is achieved by combination of bisacodyl orally and rectally, the latter guarantees emptying of the rectum /3, 4, 26/.

Sodium picosulfate is freely soluble in water /23, 27/. The active metabolite exists in the large intestine only, by influence of bowel sulfatase enzymes. Thus the hydrolysis of sodium picosulfate is attributable to the presence of microorganisms from the flora of the large intestine /22, 23/.

As sodium picosulfate is without activity in the stomach, no coating of the substance is necessary to avoid local side effects. This makes it possible to manufacture a sodium picosulfate - magnesium citrate powder. Such a mixture of laxative and saline is easily dissolved in water and can be given as a simple single medication /21, 28/.

Material and Methods

Patients scheduled for double-contrast enema (DCE) at our department were entered into a randomized study comparing 12 different colon cleansing regimens. All received written information and gave their consent (Helsinki Documents, 1975). A three-step study was performed with consecutive, nonhospitalized adult patients: 600 patients in the first part, 420 in the second, and 180 in the third.

The receptionist gave each patient a small, neutral box, identifiable by a serial number. Each package contained the medication, an instruction form, and a recommended diet. A questionnaire was included on which to note personal comments about application, taste, number of evacuations, and work capacity on the day of the bowel preparation. The examining doctor completed the questionnaire by an interview.

All the radiographic examinations of the colon were performed in accordance with the routine DCE technique described by Fischer and Welin /29 - 31/. The radiologist, departmental personnel, and the patient were not informed about the type of colon preparation. The films were interpreted separately and judged with regard to colon cleansing by two independent radiologists using a prearranged scoring system (Table 1). The final radiological diagnoses in the first 600 patients were also noted and tabulated.

The regimens were started the day before the examination and were identical concerning diet recommendations, i.e. low-bulk food and a minimum of 2 liters of clear liquids. Table 2 shows the compositions of the 12 regimens, 6 in part 1, and 3 in parts 2 and 3, respectively.

Results

There were 552 patients in the first part of the study, 388 in the second, and 163 in the third. Ninety-seven patients were excluded, mostly because they had not undergone DCE or had failed to comply with fluid and medication intake or diet restrictions.

There was no significant difference in judgment of fecal residue between the 2 interpreting doctors. In 10% of the evaluations there was disagreement concerning score number, but never exceeding one degree.

The distribution of sex ratios among groups was heterogeneous at a low level of significance ($\chi^2 = 20.370$, $df = 11$, $p < 0.05$). This was mainly due to a reverse sex ratio in the regimen group 3. The mean age did not differ among groups (Table 3).

Table 4 shows the cleansing scores achieved by the different regimens. Regimens 1-6 were homogeneous concerning cleansing scores (Kruskal-Wallis test with corrections for tied observations). The same was true for regimens 7-9 and 10-12. When parts 1 and 2 were compared with the whole group (with regard to number of acceptably cleansed patients with score values 1 and 2), differences of highest significance were seen ($\chi^2 = 33.469$, $df = 1$, $p < 0.001$). Comparing

TABLE 1. Scoring system (scores 1 and 2 are accepted in routine clinical work; score 4 is never accepted)

Score	Description
1 = Excellent	No retained fecal material visible on DCE films of the colon
2 = Good	Minimal fecal material not interfering with interpretation of the DCE
3 = Fair	Moderate fecal debris - small polyps up to 5 mm could not be excluded
4 = Poor	Considerable fecal residue, sufficient to compromise the examination

TABLE 2. Compositions of the different regimens and their application times on the day prior to examination (enemas were given on the day of examination)

Compound	Application time	Regimen number											
		Part one				Part two				Part three			
		1	2	3	4	5	6	7	8	9	10	11	12
Cascara-Sagrada (mg)	8 a.m., 4 p.m.	60											
Bisacodyl (mg)	Noon, 9 p.m.	10						10			10		
Sodium picosulfate (mg)	8 a.m., 4 p.m.			5	5	0	0 a.m. 10 p.m.		5	10		5	10
Magnesium sulfate (g)	8 a.m., 4 p.m.	7.5											
Magnesium oxide (g)	8 a.m., 4 p.m. 8 a.m., noon			1.75	2.75	2.75	2.75	1.8	3.5	3.5		3.5	3.5
Bisacodyl micro-enema (mg)	6 a.m.	10						10			10		
Water enema (l)	1 hour before examination										2	2	2

TABLE 3. Mean age of the patients and sex distribution in the 12 groups

Regimen number												
Part one			Part two				Part three					
1	2	3	4	5	6	7	8	9	10	11	12	
Mean age	58.1	56.3	57.4	57.6	53.1	56.9	55.0	52.1	50.4	54.6	52.5	45.6
No. of women	61	57	38	55	54	50	78	72	86	28	26	29
No. of men	28	37	54	37	40	41	50	54	48	26	31	23

TABLE 4. Number of patients as related to cleansing scores and regimens

Cleansing scores	Regimen number													
	Part one						Part two				Part three			
	1	2	3	4	5	6	Total	7	8	9	Total	10	11	12
1	23	22	15	16	15	20	111	55	49	55	159	36	42	40
2	35	41	35	47	44	31	233	44	52	56	152	14	14	10
3	22	19	27	21	29	24	142	18	15	13	46	2	1	2
4	9	12	15	8	6	16	66	11	10	10	31	2	0	0
Total	89	94	92	92	94	91	552	128	126	134	388	54	57	52
							163							

parts 2 and 3 in the same way, differences of highest significance were again seen ($\chi^2 = 20.296$, $df = 1$, $p < 0.001$).

Figure 1 presents the overall results in the 3 parts of the investigation. Figure 2 shows the percentage of acceptably cleansed colons, i.e. those with achieved score numbers 1 and 2.

Table 5 lists the cleansing scores in part 1 of the investigation in relation to final radiological diagnoses. The cleansing scores obtained initially were not related to the colon findings ($\chi^2 = 10.0$, $df = 9$, $p > 0.05$).

Table 6 shows the cleansing results obtained in relation to the patients' age groups. No significant difference in cleansing results among age groups was observed ($\chi^2 = 11.193$, $df = 6$, $p > 0.05$ for part 1).

Table 7 shows the number of patients who experienced adverse effects with different regimens and the percentage of patients with symptoms. The symptoms are specified in Table 8. Parts 1 and 3 of the study show no significant differences in occurrence of side effects among the regimen groups. However, in part 2, regimen group 9 showed a clearly higher incidence of adverse symptoms ($\chi^2 = 11.081$, $df = 2$, $p < 0.01$).

Table 9 shows the judgment of taste and regimen performance of medication in part 1: 47%-57% of the patients had no definite view about taste. However, the number of patients complaining of distaste and difficulty in carrying through was significantly higher in regimen 1 ($\chi^2 = 49.182$, $df = 1$, $p < 0.001$ for taste; and $\chi^2 = 15.940$, $df = 1$, $p < 0.001$ for carrying through).

There was no significant difference concerning number of evacuations in the treatment groups.

The fulfillment of daily work was limited on the day of bowel preparation according to 96 of 551 patients in part 1. The incidence of reduced activity did not differ significantly among the regimens. Most of these patients belonged to occupational groups such as drivers and industrial workers.

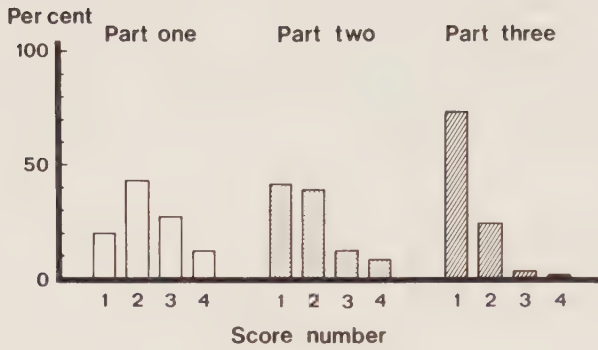


Fig. 1. Overall cleansing results in the 3 parts of the investigation given as percentages

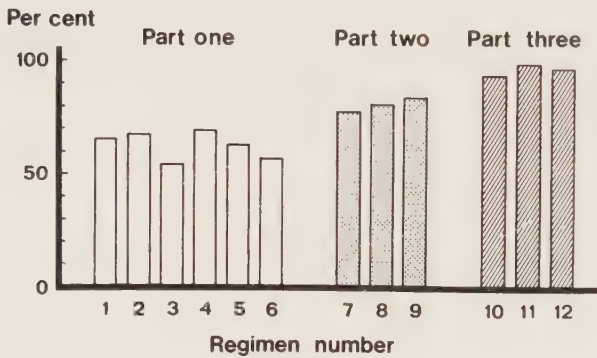


Fig. 2. Percentage of patients with acceptably cleansed colon (score 1 + 2) in the different regimens

TABLE 5. Number of patients in part I as related
to cleansing scores and final diagnosis

Score	Diagnostic finding ^{x/}				Total
	N	I	S	X	
1	36	6	21	48	111
2	92	16	24	101	233
3	58	4	16	64	142
4	22	4	7	33	66
Total	208	30	68	246	552

^{x/} N, normal colon; I, inflammatory disease; S, neoplastic disease; X, other colonic disease or finding

TABLE 6. Patients in the 3 different parts of the investigation as related to cleansing score and age

Part of the investigation	Score	Age in Years			Total
		<30	30-69	>69	
One	1	5	83	23	111
	2	22	167	44	233
	3	16	93	33	142
	4	7	37	22	66
Two	1	13	132	14	159
	2	17	122	13	152
	3	8	32	6	46
	4	3	26	2	31
Three	1	12	106	0	118
	2	6	31	1	38
	3	1	4	0	5
	4	0	2	0	2

TABLE 7. Number of patients with side-effects (A)

Regimen number												
Part one			Part two				Part three					
1	2	3	4	5	6	7	8	9	10	11	12	
(A)	28	27	19	32	26	30	48	36	66	11	10	16
Total	89	94	92	92	94	91	128	126	136	54	57	52
Percent of total	32.6	28.7	20.7	34.8	27.7	33.0	37.5	28.6	48.5	20.3	17.5	30.8

TABLE 8. Number of patients with specified symptoms

Symptom	Regimen number											
	Part one				Part two				Part three			
	1	2	3	4	5	6	7	8	9	10	11	12
Heavy diarrhea												
Abdominal pain												
Distention												
Anal pain	10	10	4	6	6	9	28	17	38	3	1	7
Vertigo												
Headache	11	10	11	20	14	14	30	21	24	7	5	11
Fatigue												
Nausea												
Miscellaneous	18	17	10	19	16	26	21	22	43	6	10	8
No. of symptoms	39	37	25	45	36	49	79	60	115	16	16	26

TABLE 9. Number of patients in part I as related to taste (A)
and performance (B)

	Regimen number					
	1	2	3	4	5	6
A. Taste of medication						
No opinion	42	54	48	51	53	45
Good	5	8	14	19	16	22
Neutral	19	29	28	18	21	19
Nasty	23	3	2	4	4	5
B. Regimen performance						
No opinion	42	55	49	51	54	47
Easy	35	35	42	38	38	40
Difficult	12	4	1	3	2	4

Discussion

The regimen able to achieve thoroughly cleansed colon in every patient has not yet been introduced, although promising results have been obtained with various techniques. The lack of cleansing difference of the purgative systems now in use is reflected in the large number of published studies /1-5, 14, 16-18, 30-37/. Several oral laxatives have been tried, including stool softeners which may not necessarily contribute to the cleansing effect /5, 38/. Whole gut irrigation (via a duodenal tube) with an electrolyte solution results in excellent cleansing of the bowel and is a safe, acceptable method suitable for selected patients, i.e. before large bowel surgery or colonoscopy /39-41/.

For radiological purposes, Welin /30, 42/ and others /35/ achieved good cleansing results with bisacodyl and tannic acid, but many patients complained of abdominal pain. McAlister et al. /35, 43/ reported a few fatalities. During the past decade, patients referred to our department were prepared with a combination of magnesium sulfate and anthraquinone derivates (Cascara-Salax), overhydration, and low-residue food /1, 3, 4, 14, 34, 44/. With this regimen clean colons were achieved in 75% as judged on DCE studies. Other investigators have reported clean colons in 85%-95% with a regimen of bisacodyl and magnesium citrate in patients studied with single-contrast enema or abdominal survey films only /3-5, 18, 44, 45/. In an effort to increase the frequency of bowels sufficiently clean for diagnostic purposes, we performed this clinical investigation and compared the effectiveness of a mixture of sodium picosulfate and magnesium oxide with purgative medications now in use.

The patients were nonhospitalized adults, which may explain the good overall results in these series. Each part of the trial was conducted on a double-blind basis, and cleansing results were evaluated by DCE, a highly sensitive procedure for assessment of residual fecal particles /2, 31, 33, 34, 46-48/.

The scoring values 1 and 2 undoubtedly constitute satisfactory examinations in routine work. Studies with score 3 are accepted in exceptional cases in old patients and when only gross pathology is to be excluded. Elective studies with score 4 are rarely suitable for diagnostic purposes.

The 3 separate parts of this investigation did not demonstrate any differences in cleansing effect between the included regimens. The increased efficacy of

sodium picosulfate as compared with bisacodyl, suggested in experimental work in humans /17/ and mice /24/, could not be documented by us.

Part 1 of the investigation compared 2 standard bowel cleansing systems, bisacodyl and Cascara-Salax, with combinations of sodium picosulfate and magnesium citrate. An increase in salt content by 30% and due to the addition of saline laxative to bisacodyl (part 2) significantly increased the cleansing efficacy. With an additional water enema, the results were still better (part 3), unequivocally suggesting the importance of a final tap water enema /33, 34/. This necessity has been denied by some authors /1, 3, 4, 18/; others have suggested additional components to the enema /32, 45/. An additional tap water enema reduced the incidence of insufficiently cleansed colons (score 4) to 1.2%. The study also indicates the importance of an optimum saline laxative content.

The assumed functional disturbance of a diseased colon did not result in an impaired colon evacuation. Furthermore, our method provided good results even in the nonhospitalized older patients, as already shown by Dodds et al. /5/.

It is an arduous task to get a valid and comparative analysis of subjective symptoms simply because up to 29% of patients who ingest placebo medication report adverse effects /28, 49/. The method used, with a questionnaire and a completing interview, was a trial to achieve pertinence in this task. The overall incidence of reported symptoms was high in this series as compared with most other studies. This might reflect that the preinformed patient more readily perceives adverse symptoms. The low incidence of side effects in part 3 perhaps reflects lesser depth of inquiry by the interviewing doctors as the investigation continued, rather than the suppression of patient's symptoms because of a final tap water enema. The amount of reported adverse symptoms was at least not under-estimated. Excluding the patients examined by the physician who recorded the highest frequency of adverse symptoms, less than 25% of the remaining patients (except for those in regimen group 9) noted adverse effects. This figure agrees with previous investigations /1, 5, 14, 16, 24, 27, 29, 47, 50, 51/.

Sodium picosulfate has a neutral taste /51/, and the patients' opinion about the regimen performance of sodium picosulfate and magnesium oxide formulation was favorable. On the other hand, almost 100 of 551 patients reported inconvenience carrying out their normal duties while on such premedication. Therefore,

patients who by profession have no immediate access to rest rooms ought to be sick-listed on the day of bowel preparation.

Acknowledgements . This work was supported by the Swedish Medical Research Council, MFR, B-80-29X-4819-05 .

References

1. Rosengren JE, Åberg T: Cleansing of the colon without enemas. Radiologe 15:421-426, 1975
2. Schilling Th: Die Doppelkontrasttechnik in der Dickdarm-Diagnostik. Röntgenblätter 30:388-399, 1977
3. Barnes MR: How to get a clean colon - with less effort. Radiology 91:948-949, 1968
4. Brown GR: A new approach to colon preparation for barium enema: preliminary report. Univ Michigan Med Bull 27:225-230, 1961
5. Dodds WJ, Scanlon GT, Shaw DD: An evaluation of colon cleansing regimens. AJR 128:57-59, 1977
6. Fringl E: Laxatives and Cathartics. In Goodman LS, Gilman A (eds): The Pharmacological Basis of Therapeutics, 5th ed. New York: Macmillan, pp 976-986, 1975
7. Harvey RF, Read AE: Saline purgatives act by releasing cholecystokinin. Lancet 11:185-187, 1973
8. Binder HJ, Donowitz M: A new look at laxative action. Gastroenterology 69:1001-1005, 1975
9. Sollman T: A Manual of Pharmacology and Its Application to Therapeutics and Toxicology, 7th ed. Philadelphia: WB Saunders Co, 1949
10. Hirschfelder AD: Clinical manifestations of high and low plasma magnesium. Danger of epsom salt purgation in nephritis. JAMA 102:1138-1141, 1934
11. Smith B: Effect of irritant purgatives on the myenteric plexus in man and the mouse. Gut 9:139-143, 1968
12. Smith B: Pathologic changes in the colon produced by anthraquinone purgatives. Dis Colon Rectum 16:455-458, 1973
13. Travell J: Pharmacology of stimulant laxatives. Ann NY Acad Sci 58:416-425, 1954
14. Nüesch HJ, Clavadetscher P, Jenny S: Dickdarmvorbereitung für Endoskopie und Radiologie. Ars Med 66:5-6, 1976
15. Rafsky GA, Newman B, Seidenberg S: Newly isolated active principles of senna: preliminary report. Am J Dig Dis 12:221-222, 1945
16. Barbi G, Fici F: Sperimentazione clinica controllata di un nuovo lassativo di sintesi: il picosulfato di sodio. (Note I). Settimana Med 55:987-994, 1967
17. Barbi G, Fici F: Sperimentazione clinica controllata di un nuova lassativo di sintesi: il picosulfato di sodio. (Note II). Settimana Med 55:997-1004, 1967

18. Weinberg CR, Baruch EA: Simplified bowel preparation for radiography and genitourinary surgery. J Urol 85:988-992, 1961
19. Kremer K, Grewe HE: Untersuchungen über die medikamentöse Beeinflussung der Darmperistaltik. Ärztl Wochenschr 10:529-533, 1955
20. Schmidt L: Pharmakologie und Toxikologie einer neuen Klasse von Verbindungen mit laxierender Wirkung. Arzneim Forsch 3:19-23, 1953
21. Schmidt L, Fülgraff G: Über einen Rectum-Colon-Reflex. Arzneim Forsch 13:217-220, 1963
22. Jauch R, Hankwitz R, Beschke K: Bis-(p-hydroxyphenyl)-pyridyl-2-methane: The common laxative principle of Bisocodyl and sodium picosulfate. Arzneim Forsch 25:1796-1800, 1975
23. Forth W, Nell G, Rummel W: The hydragogue and laxative effect of the sulfuric acid ester and the free diphenol of 4,4'-di-hydroxydiphenyl-(pyridyl-2)-methane. Naunyn-Schmiedeberg's Arch Pharmacol 274:46-53 1972
24. Pala G, Coppi G, Crescenzi E: On the laxative properties of sulfuric esters of phenols, with particular reference to 4,4'-(2-picolylidene)-bis-phenylsulfuric acid disodium salt (Picosulfol). Arch Int Pharmacodyn Ther 164:356-369, 1966
25. Saunders DR, Sillery J, Rachmilewitz D: Effect of Bisacodyl on the structure and function of rodent and human intestine. Gastroenterology 72:849-856, 1977
26. Brown GR: Preparing the colon for radiological study. Mod Med 38:200-201, 1970
27. Evangelisti GB, Farina O: La stipsi cronica abituale (e suo trattamento con il sale bisodico dell'acido 4,4'-(2-picoliliden)-bis-fenilsoforico). La Clinica 27:182-196, 1967
28. Schürger R: Die Routinelaxation und eine sachgemässe individuelle Behandlung der Obstipation. Therapiewoche 22:1873-1876, 1972
29. Fischer AW: Über die Röntgenuntersuchung des Dickdarmes mit Hilfe einer Kombination von Lufteinblasung und Kontrasteinlauf. Arch Klin Chir 134: 209-269, 1925
30. Welin S: Modern trends in diagnostic roentgenology of the colon. Br J Radiol 31:453-464, 1958
31. Welin S: Über die röntgenologische Untersuchung des Dickdarmes mit der Doppelkontrastmethode. Die Malmömodifikation. Radiologe 2:87-100, 1962
32. Welin G, Welin S, Åberg T: Klyxray: a new preparation for excessive emptying of the colon. Br J Radiol 43:744-746, 1970

33. Miller RE: The cleansing enema. *Radiology* 117:483-485, 1975
34. Miller RE: The clean colon. *Gastroenterology* 70:289-290, 1976
35. Diner WC, Dodd D, Riggs OE: The value of Bisacodyl Tannex (Clysodrast) in the radiological examination of the colon. *Radiology* 104:49-51, 1972
36. Margulis AR, Goldberg HI: The current state of radiologic technique in the examination of the colon: a survey. *Radiol Clin North Am* 1:27-42, 1969
37. Tracht DG, Clemett AR: An evaluation of the "clean colon" technique. *Radiology* 99:69-70, 1971
38. Ennis JT, Mitchell AV: Oral laxatives in barium enema preparation. *Br J Radiol* 43:242-244, 1970
39. Hewitt J, Rigby Janet, Reeve J: Whole-gut irrigation in preparation for large-bowel surgery. *Lancet* II:337-340, 1973
40. Levy AG, Benson JW, Hewlett EL: Saline lavage: a rapid, effective, and acceptable method for cleansing the gastrointestinal tract. *Gastroenterology* 70:157-161, 1976
41. Skucas J, Cutcliff W, Fischer HW: Whole-gut irrigation as a means of cleaning the colon. *Radiology* 121:303-305, 1976
42. Welin S: Closydrast. *Observanda Medica*, Ferrosan, Sweden, 1955
43. McAlister HW, Anderson MS, Bloomberg GR: Lethal effects of tannic acid in the barium enema. Report of three fatalities and experimental studies. *Radiology* 80:765-773, 1963
44. Barnes ME: Clean colon without enemas. *Am J Nurs* 69:2128-2129, 1969
45. Cattani E, Pavlica P: Elimination of intestinal gas prior to radiographical examination of the urinary tract. *Quad Radiol* 34:171-182, 1969
46. Andrén L, Frieberg S, Welin S: Roentgen diagnosis of small polyps in the colon and rectum. *Acta Radiol Diagn* 43:201-208, 1955
47. Laufer I: The double-contrast enema: myths and misconceptions. *Gastro-intest Radiol* 1:19-31, 1976
48. Sanders RC, Wright FW: Colonic preparation: a controlled trial of Dulcodos, Dulcolax and Senkot DX. *Br J Radiol* 43:245-247, 1970
49. Newman DE, Fellows KE Jr: A double-blind study of ipodate and the non-diagnostic cholecystogram. *J Can Assoc Radiol* 21:149-152, 1970
50. Mertens H: Beurteilung eines neuen Laxativums (Laxoberal) nach einer multilokulären Prüfung. *Therapiewoche* 22:2956-2960, 1972
51. Weist FR: Erste klinische Erfahrungen mit einem neuen Laxativums in Tropfenform. *Therapiewoche* 22:2810-2814, 1972

From the Department of Diagnostic Radiology, University of Lund, Malmö
General Hospital, Malmö, Sweden

RELIABILITY OF ROUTINE DOUBLE-CONTRAST

EXAMINATION OF THE LARGE BOWEL

A prospective study of 2590 patients

F-Th FORK

Summary. Totally, 2590 consecutive patients referred for double-contrast examination of the large bowel (DCE) were followed up radiographically, clinically, endoscopically, and histopathologically during a four-year period. The patients were assorted into two groups on the basis of the presence or absence of radiographic evidence of colonic disease at the first, i.e. index, examination. By comparing the findings obtained at the index DCE's with those obtained during follow-up, the sensitivity, specificity, and accuracy of the index DCE were all calculated at 0.84. The predictive value of a positive report was 0.93 and that of a negative report 0.72. However, if patients with normal DCE's at the start of this series and not examined further during the follow-up period were accepted as free from significant colonic disease, the predictive value of a negative report increased to 0.94. DCE is thus a reliable method for demonstrating the presence of colonic lesions and thereby considerably facilitates the choice of treatment in a given case.

Introduction

Cumulative clinical and experimental evidence suggests a strong connection between benign neoplastic polyps and carcinoma of the colon and rectum, indicating a tendency of the former to be the site of development of later gross malignant lesions.¹⁻¹⁰ This fact provides cogent argument for the routine use of a radiographic procedure that is capable of detecting even minor polyps, especially since such lesions can now easily be removed through the colonoscope.^{8,11,12} In an attempt to assess the accuracy of the double-contrast examination of the large bowel - henceforth to be referred to as DCE - and thereby to facilitate the clinical management of the patients in the light of the radiologist's report, a prospective study of patients, who were followed up for 40 - 48 months, was initiated.

Methods

Patients

The clinical DCE material originally consisted of 2590 consecutive patients (1155 men and 1435 women) (Fig. 1) who underwent radiographic examination of the colon within a nine-month period beginning in May 1976. These patients were carefully followed up until June 1980.

However, 55 of these patients were excluded because they had been examined with the single contrast method and 164 (mean age 60 years, range 4 - 95) because the patient could not co-operate ($n = 46$). This left 2371 patients for the present study who had been examined with DCE (index DCE). During the follow-up period, 390 patients were re-examined once and 177 others twice or more with DCE. The total number of DCE examinations was 3405.

Of the total number of patients included in this prospective study, 962 had had a DCE examination previous to the initiation of this series.

The findings made at repeat DCE and colonoscopy, at operation, and at pathologic examinations were collected. In cases with rectal lesions according to the DCE or in the event of discord between the DCE and rectoscopy, the findings at rectoscopy (rigid instrument) were collected, i.e. from 348 examinations in 296 patients. Colonoscopy was performed 170 times in 140 patients and surgery 155 times in 145; 137 patients were autopsied. Totally, 793 tissue specimens from 650 patients were examined histologically and the findings were included in this series.

The patients' symptoms and the findings at earlier clinical examinations, as well as the indications for the first radiographic study, were noted, as were comments on previous DCE studies. In 2535 patients the index radiographic examinations were performed in accordance with the DCE method, detailedly described by Fischer, Weber, Welin, and others.¹³⁻²¹

Routinely, every DCE at Malmö General Hospital is interpreted by two radiologists, one writing the report on the examination and the other demonstrating it to the clinicians. During the present series the DCE's were also separately interpreted by two other independent, experienced radiologists who were

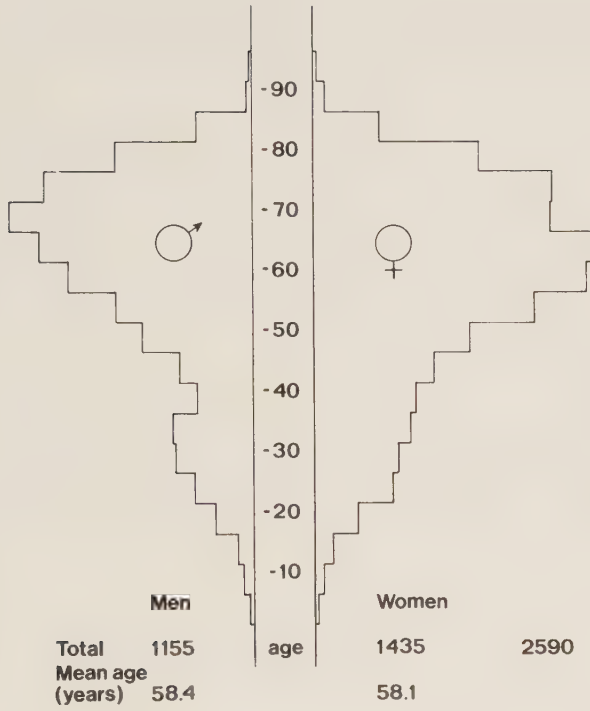


Fig. 1. Age and sex distribution of all 2590 patients. One patient was only nine months old at referral for DCE.

unaware of previous clinical and radiographic reports. The interpretations were virtually always concordant and after three months, only one radiologist, the author, interpreted the remaining DCE's. If a positive result of a given examination did not accord with the previous, routinely written report, a new one was sent to the clinician. Thus, at least three independent radiologists had seen all the roentgenograms.

The patients were prepared for the examination in the way described previously.²²⁻²⁴ Ratings with regard to the radiographic technique were made, as was the assessment of the overall diagnostic quality of the study; score 1: Adequate study; score 2: Some reservation, not interfering with the diagnostic interpretation; score 3: Restricted quality; and score 4: Not interpretable, corresponding to the 164 excluded patients.

Each DCE was categorized as normal, N, or abnormal, aN. In the latter case the lesions were defined as neoplastic, inflammatory, degenerative, or of other origin, and when possible, the lesions were grouped according to their position between the caecum and the rectum.

Results

The number of accepted index DCE's in this series was 2371. In 1101 patients the index DCE was within normal limits, but nevertheless 137 patients were re-examined once and 48 at least twice during the observation period (Tables 1 and 2 B). In 409 of the 1101 patients, DCE's had been performed previous to the index study.

The changes observed in the remaining 1270 patients (Table 2 A, B) consisted merely of diverticulosis without signs of inflammation in 536 and various minimal findings - such as normal mucosa after major bowel surgery, spasm, or haemorrhoids alone - in 92. This left 642 patients with significant changes. Of these, 193 were re-examined once and 110 other at least twice. In 553 patients, DCE's had been made previous to the index study.

TABLE 1. Number of patients with normal and abnormal index DCE's and one or more follow-up DCE's. Numerals in parentheses denote patients with DCE studies prior to the index one

	D C E d i a g n o s e s			
	normal		abnormal	
Index DCE	1101	(409)	1270	(553)
First follow-up DCE	185	(115)	340	(157)
Subsequent DCE's	48	(35)	111	(48)

TABLE 2 A. Number of patients according to diagnoses

I n d e x D C E	
Diagnoses	No. of patients
Normal	1101
Abnormal	1270
(significantly abnormal 642)	
(diverticulosis 536)	
(miscellaneous 92)	
Excluded	219
Total	2590

TABLE 2 B. Number of patients examined once, twice, and three times with DCE, divided into those with normal, N, and abnormal, aN, DCE reports

Diagnoses at index DCE	No. of patients studied with				
	One DCE	Two DCE's		Three DCE's	
		N	aN	N	aN
Normal	916	137		48	
Diagnoses at follow-up DCE's		108	29	34	11
Significantly abnormal	339	193		110	
Diagnoses at follow-up DCE's		35	158	7	82

Verification with DCE

A. Index DCE normal (Table 2 A, B, Fig. 2 A, numerals within columns).

At the first follow-up, the DCE still showed nothing abnormal in 108 patients, but displayed earlier undiagnosed colonic lesions in 29 (diverticula in five; polyps in 10; deformities due to extra colonic lesions in four patients; recurrent carcinoma in two; sequelae of irradiation in two; and mucosal inflammation in six). At the second follow-up, polypoid lesions were confirmed in 11 patients, whereas in two others such polyps were excluded, thus confirming the index DCE. Further, in one patient a third examination revealed a previously undetected polyp.

B. Index DCE abnormal (Table 2 A, B, Fig. 2 B, numerals within columns).

The first follow-up of the 642 patients with significant colonic lesions at the index DCE still showed colonic changes in 158, but no longer in 35 (inflammatory lesions were no longer demonstrable in 11, although rectal biopsy in six revealed such lesions; the diagnosis of polyps at index DCE proved false positive in eight; polyps were removed after the index DCE in 13; and in three patients, deformities of the colon had disappeared).

The second follow-up confirmed lesions in 91 patients. In 19 other patients, polypoid lesions had been removed after the index DCE in four and after the first follow-up examination in 12, whereas rectal changes seen in three patients at the index DCE were no longer demonstrable.

Verification with other methods

A. Index DCE normal (Fig. 2 A, numerals at arrows).

Available tissue specimens from 80 patients without any demonstrable colonic abnormality at the index DCE showed missed polyps in 22 and mucosal inflammation in 12, whereas in 46 (total colonoscopy in three and autopsy in 43) the specimens confirmed the normality of the large bowel. In another 26 patients, rectal biopsy showed nothing pathological. Of the 108 patients in whom neither the index DCE nor repeated roentgenography had disclosed anything abnormal, colonoscopy revealed polyps in five, whereas colonoscopy in one and autopsy of seven confirmed the normal appearance.

In 14 out of the 29 patients with radiographic changes at follow-up, post-mortem examinations were performed: in 13 the changes seen at DCE were proved and in one patient who had had a polyp removed endoscopically, no additional pathological changes were found. Of the 34 patients in whom a second DCE had

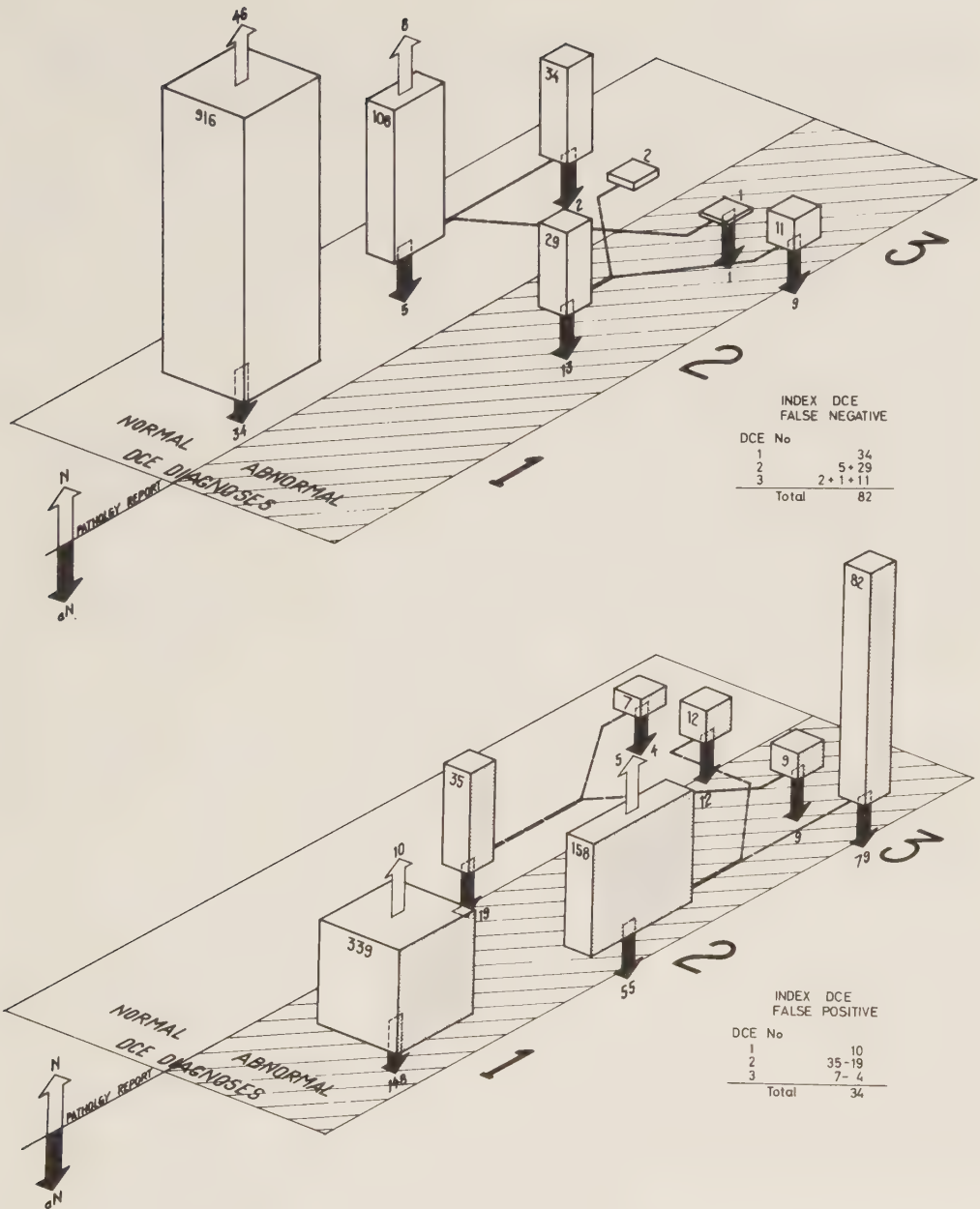


Fig. 2. Number of patients with normal, A, and abnormal, B, index DCE's divided according to diagnoses at subsequent DCE's - columns - and to pathology reports - arrows. (N = normal, aN = abnormal.)

shown no changes, specimens from two patients with macroscopically normal rectoscopies displayed mild, non-specific inflammatory changes.

Of 11 patients with demonstrable polypoid changes at the second follow-up DCE, tissue specimens from nine were available and inflammation was seen in three specimens and polypoid tissue in six. In the single patient with normal follow-up DCE's, biopsy specimens displayed polypoid tissue.

B. Index DCE abnormal (Fig. 2 B, numerals at arrows)

In the 339 patients with radiographically significant colonic changes studied only once with DCE, the microscopic examination confirmed colonic lesions in 148 of these patients, but not in 10 (total colonoscopy in 12 confirmed mucosal changes in 10, whereas biopsy specimens from two with quiescent ulcerative colitis and three with proctitis, at DCE and rectoscopy, were essentially normal; autopsy in 73 patients confirmed the lesions in all but five, i.e. no diverticular changes were seen; operation of 44 patients confirmed the radiographic changes in all; and rectoscopic biopsy specimens, in 26 others).

Of the remaining 303 patients, i.e. those examined with one or two follow-up DCE's (Table 2 B, Fig. 2 B), histologic examination of available specimens from 188 confirmed the radiographic changes in 183 but not in five (subtle inflammatory disease shown at two DCE's in three patients, specimens of the rectum appeared essentially normal; an autopsy of two other patients failed to disclose any polyp in one and diverticular degeneration in another). Thus, at the index DCE there was an overdiagnosis in 34 patients but a correct diagnosis in 427 (Fig. 2 B). Table 3 shows the number of over- and underdiagnoses. By placing the number of patients with verified normal and abnormal DCE's into a decision matrix, the sensitivity, specificity, and accuracy of a given DCE report was defined.^{25,26} Table 4 shows the results after the review of the follow-up procedures. The sensitivity (defined as the quotient between the true positive studies and the number of diseased patients) and the specificity (the quotient of the true negative studies to the number of non-diseased patients) were respectively 0.84. The accuracy (defined as the quotient between the sum of the true positive plus negative patients and the whole groups) was also 0.84.

TABLE 3. Number of patients with false index diagnosis proved by the follow-up studies.

A. false negative diagnoses

B. False positive diagnoses

	Total	Polyps	Colitis	Diverticula	Other lesions
A. Number of false negative index diagnoses	82	49	20	5	8
B. Number of false positive index diagnoses	34	9	9		6

TABLE 4. Number of patients with proved diagnosis of the index DCE's in a decision matrix. N = normal study, aN = abnormal study

Index DCE	Result from follow-up studies		Total
	aN	N	
aN	427	34	461
N	82	183	265
Total	509	217	726

Sensitivity: $427/509 = 0.84$

Specificity: $183/217 = 0.84$

Accuracy: $(427 + 183)/726 = 0.84$

The predictive value of a positive DCE: $427/461 = 0.93$

The predictive value of a negative DCE: $183/265 = 0.70$

Discussion

As has been shown in earlier studies,⁵ Malmö is very suitable for epidemiologic studies: one hospital for somatic diseases, serving a well-defined population with a small annual percentage of people moving in and out, varying between 3.8 and 4.5 % from 1958 to 1980. During this period the population increased from 221,664 to 233,000 (Statistical Department of the City of Malmö). Although the incidence of colorectal cancer is higher in southern Sweden than in the rest of the country,^{27,28} the presented results of the roentgenography with the DCE method for colonic disease can probably be regarded as representative and valid for similar populations in Western industrialized countries.

The patients in our series were routinely referred for DCE, i.e. without previous general screening for colonic diseases. The mean age of the patients was 60 years (range nine months - 95 years), and the sex distribution was the same as in a series from our department in 1962.¹⁹

Since 1953, a radiographic examination of the colon has been routinely performed with the DCE method. Only crippled, old people with chronic disorders or patients with acute colonic obstruction were examined with the single contrast procedure.

The initial aim of the study was to compare the diagnostic yield obtained at DCE with that obtained at single contrast radiography of the colon. This was, however, deemed unacceptable for ethical reasons, for the patient would have to be examined with both techniques on two separate occasions. Thus, to assess the diagnostic yield of the DCE procedure, the patients were followed up until July 1980, it being assumed that any significant colonic or pericolonic disorder missed (carcinoma, inflammatory bowel disease, etc.) would be detected within this time. Most of the patients were not re-examined, a fact indicating absence of at least major colonic disorders.

The pathologist's reports on biopsy and autopsy specimens were regarded as proof of the presence or absence of large bowel disease. The results of clinical, endoscopic and repeat roentgenographic studies during the follow-up period were thought to be the only way to come closer to the clinical truth and to avoid any bias in the evaluation of the figures when calculating the accuracy of the DCE method.

Uncomplicated diverticula of the colon are common in the old and middle-aged population and are often asymptomatic. This group of patients was considered as not presenting significant disease or normal large bowels, and was consequently not included in the calculations of the above-mentioned parameters.

The DCE studies before the index DCE were carried out several months to years before the beginning of our investigation (Table 1). A retrospect analysis of these studies was considered to lie beyond the scope of the present study. However, the number of such earlier examinations was significantly larger in patients with an abnormal index DCE than in patients with a normal one ($\chi^2 = 10.39$, $p < 0.001$) indicating that abdominal symptoms in these patients were presumably referable to the large bowel.

The only way to offer the patient and his physician a test report of high accuracy is to comply with the prerequisites of the test itself. In this series, the test demands aimed at the patient were acceptably cleansed bowel and absence of moving artefacts. The percentage of patients who did not fulfill these criteria was 8.5 % -viz. 118 (4.6 %) failed to comply with the instructions for bowel preparation; 55 (2.1 %) were in a poor general condition; and 46 (1.8 %) could not co-operate. Of these last 101 patients, 60 % were 70 years of age or older.

Several reports on polyp detection and DCE indicate a high sensitivity of the method, i.e. detection of a high percentage of known polyps.²⁹⁻³¹ But hitherto no attention has been given to the specificity, i.e. the number of normal DCE's versus the true number of non-diseased large bowels, or to the overall accuracy of the DCE. Nor have patients been followed up for several years to disclose any colonic lesions primarily overlooked. Besides, no efforts have been made to calculate the diagnostic capacity of DCE, i.e. the predictive values of positive and negative DCE reports. Such figures are of great interest to physicians in their daily work²⁶⁻³² for assessing the reliability of any laboratory examination. They are expressed as the quotient between the number of true positive roentgen examinations and the total number of positive DCE's and the true number of negative ones to the total number of negative DCE studies, i.e. in our investigation, 427/461 and 183/265, respectively, yielding quotients of 0.93 and 0.70. In other words, the risk of a false positive DCE in a given case was 7 % and that of a false negative almost 30 %. However, the remaining 848 patients with normal index DCE's and not examined further during the four-year follow-up were certainly free from significant colonic disease at the time of the index DCE,

as these patients have not reappeared during this follow-up period. Inclusion of these patients in the decision matrix raised the diagnostic specificity to 1031/1113, i.e. 0.93, which means that 93 out of 100 negative reports were correct. It should be kept in mind that these figures were obtained in clinically selected patients, which explains the high prevalence of colonic disease in this series, i.e. 70 % (509 diseased patients of 726 patients followed up).

Conclusions

Routine roentgenography with adequate DCE is documented as being a reliable method for detecting or excluding patients with diseases of the colon. Assuming the absence of a colonic disorder in a patient with a normal index DCE and not further examined during at least 40 months to be correct, the DCE diagnosis was valid in 93 out of 100 instances.

Acknowledgement

This work was supported by the Swedish Medical Research Council, Project No. B79-29X-4819-04.

References

1. Fitzgibbon G, Rankin FW: Polyps of the large intestine. Surg Gynecol Obstet 1931; 52:1136 - 50
2. Swinton NW, Warren S: Polyps of the colon and rectum and their relation to malignancy. JAMA 1939; 113:1927-33
3. Hultborn KA: The causal relationship between benign epithelial tumors and adenocarcinomas of the colon and rectum. Acta Radiol Suppl 1954; 113:1-71
4. Gilbertsen VA: Proctosigmoidoscopy and polypectomy in reducing the incidence of rectal cancer. Cancer 1974; 34:936-9
5. Ekelund G: Colorectal polyps and carcinoma with special reference to their interrelationship. Thesis, Lund, 1974
6. Ekelund G, Lindström C: Histopathological analysis of benign polyps in patients with carcinoma of the colon and rectum. Gut 1974; 15:654-63
7. Enterline HT: Polyps and cancer of the large bowel. Pathology of the gastrointestinal tract. Curr Top Pathol 1976; 63:95-141
8. Gabrielsson N, Granqvist S, Ohlsén H, Sundelin P: Malignancy of colonic polyps. Diagnosis and management. Acta Radiol Diagnosis 1978; 19:479-95
9. Lane N, Fenoglio CM: The adenoma - carcinoma sequence in the stomach and colon. Gastrointest Radiol 1976; 1:111-9
10. Ekelund GR: Cancer risk with single and multiple adenomas: synchronous and metachronous tumors. In: Winawer S, Schottenfeld D, Sherlock R.eds.: Colorectal Cancer: Prevention, Epidemiology and Screening. New York, Raven Press, 1980; 151-5
11. Wolff WI, Shinya H: Colonfiberoscopy. JAMA 1971; 217:1509-12
12. Wolff WI, Shinya H: Colonofiberoptic management of colonic polyps. Dis Col Rect 1973; 16:87-93
13. Fischer AW: Über eine neue röntgenologische Untersuchungsmethode des Dickdarms: Kombination von Kontrasteinlauf und Luftaufblähung. Klin Wchnschr 1923; 2:1595-8
14. Fischer AW: Über die Röntgenuntersuchung des Dickdarms mit Hilfe einer Kombination von Lufteinblasung und Kontrasteinlauf. Langenbecks Arch Chir 1925; 134:209-69
15. Weber HM: The roentgenologic demonstration of polypoid lesions and polyposis of the large intestine. AJR 1931; 25:577-89
16. Weber HM: Carcinoma of the colon: Its roentgenologic manifestations and differential diagnosis. Amer J Cancer 1933; 17:321-41

17. Welin S: Modern trends in diagnostic roentgenology of the colon. Brit J Radiol 1958; 31:453-64
18. Welin S: Über moderne röntgenologische Dickdarmdiagnostik unter besonderer Berücksichtigung der Doppelkontrastmethode. Münch med Wchnschr 1958; 100:1142-4
19. Welin S: Über die röntgenologische Untersuchung des Dickdarmes mit der Doppelkontrastmethode. Radiologe 1962; 2:87-100
20. Hettler M: Zur Technik der Doppelkontrastdarstellung des Dickdarms. Radiologe 1962; 2:115-24
21. Miller RE, Brahme F: The clarity of good technic. Amer J Dig Dis 1967; 12: 418-20
22. Brown GR: A new approach to colon preparation for barium enema: Preliminary report. Univ Mich Med Bull 1961; 27:225
23. Barnes MR: How to get a clean colon - with less efforts. Radiology 1968; 91:948-9
24. Rosengren JE, Åberg T: Cleansing of the colon without enemas. Radiologe 1975; 15:421-6
25. Lusted Lee B: Decision-making studies in patient management. New Engl J Med 1971; 284:416-24
26. Galen RS, Gambino SR: Beyond normality: the predictive value and efficiency of medical diagnoses. New York: John Wiley and Sons, 1975
27. Cancer incidence in Sweden, 1977. The Swedish Cancer Registry. The National Board of Health and Welfare, Stockholm, 1977
28. Causes of Death 1976. National Bureau of Statistics, Stockholm, 1976
29. Ott DJ, Gelfand DW, Wu WC, Kerr RM: Sensitivity of double-contrast barium enema: emphasis on polyp detection. AJR 1980; 135:327-30
30. Fork F-T: Resultatvergleich zwischen der Doppelkontrastuntersuchung des Dickdarms und der Koloskopie mit Biopsie. In: Welin S, Welin G., eds: Die Doppelkontrastuntersuchung des Dickdarms, Erfahrungen mit der Welin-Modifikation. Stuttgart: Georg Thieme Verlag, 1980
31. Fork F-T: Double contrast enema and colonoscopy in polyp detection. Gut 1981; 22:971-7
32. Wulff HR: Rationel Klinik. (In Danish), Copenhagen: Scand Univ Books, Munksgaard, 1973

From the Departments of Diagnostic Radiology^{1/}, Pathology^{2/} and Surgery^{3/},
Malmö General Hospital, University of Lund, S-214 01 Malmö, Sweden

THE RELIABILITY OF ROUTINE DOUBLE-CONTRAST
EXAMINATION (DCE) OF THE LARGE BOWEL IN
POLYP DETECTION

A prospective clinical study

FRANS-THOMAS FORK^{1/}, CLAS LINDSTRÖM^{2/} and GÖRAN R EKLUND^{3/}

Shortened title: DCE in Polyp Detection

Abstract

A total of 2,118 consecutive patients, examined with double-contrast examination of the large bowel (DCE), were followed radiographically, clinically and endoscopically for up to 48 months.

A total of 402 polyps were diagnosed during the follow-up period. Of these, 307 were revealed at the first DCE and 95 at subsequent endoscopy or autopsy.

The accuracy of the DCE examination for demonstrating or excluding patients with polypoid lesions of the colon was 97 %, whereas the predictive value of a positive DCE report was 96 % and a negative one, 97 %. However, the ability to demonstrate every known polyp at DCE was only 63 %, though the probability of a polypoid lesion demonstrated at DCE of being a true polyp was 92 %.

Key words: Barium enema examination - Colon roentgenography - Colorectal polyps - Colon histopathology - Medical statistics - Medical decision making

Introduction

The ideal approach of treating cancer of the large bowel is prevention. Because circumstantial evidence indicates an intimate relationship between benign polyps and carcinoma of the large intestine /1 - 14/, it seems desirable to detect and remove all polyps before they degenerate into malignant lesions (Fig. 1).

Because patients with precancerous lesions of the large bowel have no characteristic symptoms /6, 14/, sigmoidoscopy has been especially recommended as a supplement to a complete physical examination /13 - 16/. Such an approach could ensure detection of 50 % of all benign polyps (Fig. 2) and 65 % of all malignant lesions of the large bowel /6, 15 - 19/. Careful periodic sigmoidoscopy of a high-risk group of patients has revealed a striking decrease in the incidence of rectal cancer /13, 20/.



Fig. 1. Male, aged 74 with diverticular disease in the sigmoid colon. An irregular polypoid lesion overlooked at DCE in 1975 (A).



B. A carcinoma was diagnosed at the same site 4 years later.



Fig. 2. Female, aged 49 years. Five polyps were diagnosed in the sigmoid colon at DCE and later removed through the colonoscope.

However, the sigmoidoscope, until recently rigid, rarely reached beyond the rectosigmoid junction /21/ and was not the ultimate explorer of all rectal polyps /22, 23/. Also colonoscopy has some diagnostic and technical limitations /24 - 27/. Because every fifth patient with neoplastic disease of the large bowel has more than one benign or malignant tumor elsewhere in the colon, it is imperative that the bowel be examined meticulously /14, 15, 28, 29/.

An effective complementary method was thus necessary. The radiographic double-contrast examination of the large bowel - henceforth to be referred to as DCE - as described by Fischer and developed into a routine clinical method by Andrén, Welin and others /30 - 37/, fulfills the desiderata /37 - 40/: it enables simultaneous visualization of the contours of the intestine and the intraluminal relief /32/.

The frequency of patients with polyps seen with the DCE technique ranges from 9.8 to 13.1 % /37, 38, 40 - 42/, figures that are comparable to the average post-mortem incidence of colonic polyps, viz. 12.5 % /17/. This shows that the DCE technique is sensitive for detecting colonic polyps and justifies radiographic /43, 44/ rather than colonoscopic follow-up after polypectomy /45, 46/.

However, many clinicians still seem to question the capacity of DCE for detecting even large lesions of the colon and therefore use colonoscopy as the primary or only diagnostic procedure /45, 47/. To define the diagnostic capacity of the DCE, a prospective study was carried out and patients were thoroughly followed up for up to 48 months.

Materials and methods

The clinical material consisted of 2,590 consecutive patients (1,155 men and 1,435 women) who underwent radiographic examination of the colon within a 9-month period from May 1976 and were carefully followed up until June 1980.

The preparations for the examination were as described previously /48, 49/. Totally, 219 patients were not accepted in this study; 55 because they had been

examined with a conventional barium enema, 118 in whom the bowel had not been properly cleansed and 46 others who could not co-operate owing to senility or severe systemic disease. Further, 253 patients with coexisting carcinomatous (n = 99) or inflammatory (n = 154) lesions were also excluded (mainly owing to the accumulation of faecal debris adjacent to a stricturing lesion, thus obscuring the mucosa, and because of the inconstant presence of inflammatory polyps in colitis).

The 2,118 patients accepted in the study were examined with the DCE method /30 - 36/. These examinations are referred to as the index DCE's.

Routinely, every DCE is examined by a senior staff member, who in turn submits a written report to the clinician. The examination is then re-read by another radiologist. In this study the DCE examinations were also interpreted independently by 2 experienced radiologists, one of whom was unaware of previous clinical and radiographic reports. In the event of discrepancies between the primary interpretation and the final one by us, the clinician was informed by letter.

Subsequent findings during a follow-up period of 48 months made at DCE studies, endoscopies, operations and at pathologic examinations were collected in an effort to define the sensitivity, specificity and accuracy of the index DCE study for detecting or excluding polypoid lesions of the large bowel. Although insufficient, the procedure with a 48-month follow-up period was considered to be the only way to come close to the true number of polypoid lesions in patients accepted in the study.

Definitions

A polypoid lesion was defined as a global mass arising from the mucous membrane and protruding into the bowel lumen. A polyp was defined as proved when it had been described as such by the pathologist; as verified when demonstrated on at least 2 occasions at DCE or seen at colonoscopy, rectoscopy or surgery. A polyp was not considered to be verified when seen at only one radiologic examination, though considered likely when seen in the same location in 3, technically good, roentgenograms. A single endoscopic examination was not considered to exclude the existence of a polyp. The absence of any demonstrable changes at repeat

DCE or endoscopy was considered necessary to exclude the presence of a polyp /50, 51/. A polyp was said to be overlooked when not depicted by the index DCE, but later proved.

Results

During the 48-months study, benign polypoid lesions were diagnosed in 271 patients (151 men and 120 women, Fig. 3). The varying technical quality of the index roentgenograms of 271 patients with and without polyps is evident from Table 1.

At the index DCE of 222 patients, 307 polypoid lesions were diagnosed; and during the follow-up period, 50 polyps were diagnosed in another 49 patients (Fig. 4). The relation in polyp detection between the index DCE and at the follow-up examinations is shown in Table 2. In 148 out of the 222 patients, all DCE-diagnosed polyps ($n = 198$) were proved. In addition, 45 polyps were seen at follow-up DCE of 22 patients. All the additional polyps were proved (Fig. 4).

The index DCE revealed polyps in 66 additional patients, verified polyps in 46 and likely in 20 others (Table 2). In 8 patients the index polyps were not DCE-verified. In 2 of these 8 patients, other polyps were diagnosed, leaving 6 patients with presumably false positive index DCE studies (Tables 2 and 10).

Another 95 polyps were diagnosed and proved at endoscopic or repeated DCE examinations in 71 patients, 22 of whom had had other polyps diagnosed at the index DCE, (Tables 2 and 9). At review of the index studies, 20 polyps were seen in retrospect in 14 patients, whereas 19 polyps in 12 could not be discriminated, despite the good quality of the roentgenograms. The remaining 46 polyps in 45 patients had been overlooked because of poor co-operation by the patient, poor general condition, advanced age, obesity, moving artefacts, unsatisfactory bowel preparation, and sometimes, though rare, the use of rectal balloons.

In all, 293 polyps were removed and examined histopathologically (Tables 3 - 5). In Table 6 the grade of histologic differentiation of 209 adenomas is given. The sites and sizes of the additional 109 DCE diagnosed polyps in 74 patients

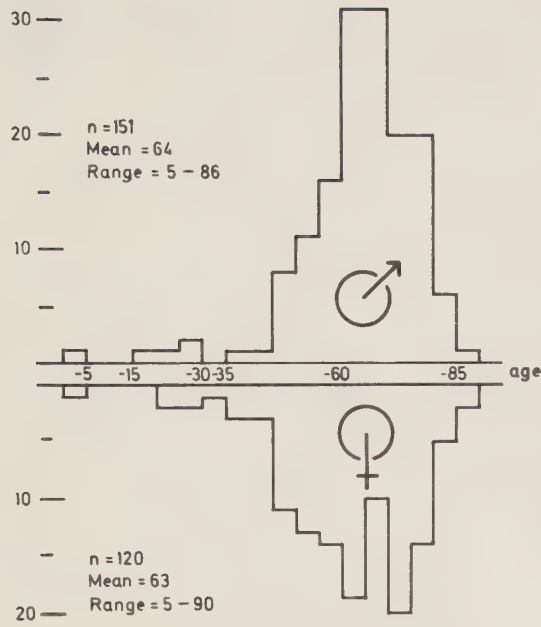


Fig. 3. Age and sex distribution of patients with polyps.

TABLE 1. Technical quality of index DCE in patients with polyps diagnosed during the follow-up period

Score	Total	I n d e x with polyp	D C E without visible polyp
Excellent	168	141	27
Good	79	64	15
Inferior	24	17	7
Total	271	222	49

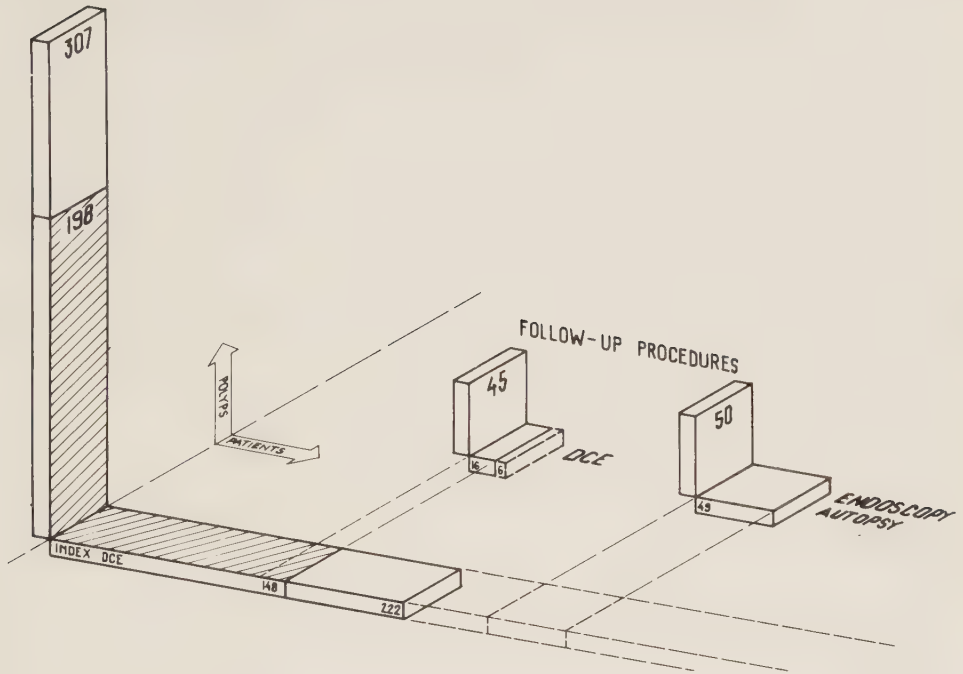


Fig. 4. Number of patients and polyps found at index DCE and follow-up procedures. Hatched columns denote number of patients with histologically examined polyps and number of such polyps found at the index DCE

TABLE 2. Number of index DCE studies with depicted polyps of various probability. Figures denote number of patients with and without additional polyps according to follow-up procedures

No. of patients with/without additional polyps at follow-up studies	Total	I n d e x		D C E w i t h p o l y p s		
		proved	verified	likely	not verified	overlooked
None at colonoscopy	123	123	-	-	-	-
None at recto- scopy only	64	-	42	20	2	-
Proved	71 (22) (49)	16	4	-	2	49
Not verified	7	5	-	-	2	-
Not excluded	4	2	-	-	2	-
Excluded	2	2	-	-	-	-
Total	271	148	46	20	8	49

TABLE 3. Number, distribution and size of polyps removed from the large bowel.
The diameter of the polyps were measured after removal

Segments of the large bowel	Total	S i z e o f p o l y p s, mm							
		0	4	5	8	10	15	20	25
Rectum	116	58	23	14	7	7	1	3	3
Sigmoid colon	78	16	11	20	11	17	2	1	-
Descending colon	40	13	9	6	6	5	1	-	-
Left flexure	10	5	3	-	-	2	-	-	-
Transverse colon	15	3	5	6	-	-	-	-	1
Right flexure	3	1	1	-	1	-	-	-	-
Ascending colon	15	6	3	4	1	-	-	-	1
Caecum	16	8	2	2	2	2	-	-	-
Total	293	110	57	52	28	33	4	4	5

TABLE 4. Number, size and histologic nature of polyps removed. The polyps were measured after removal

Type	Total	S i z e o f p o l y p s , mm							
		0	4	5	8	10	15	20	25
		.	.	.	.	.	.	.	.
Metaplastic polyps	60	48	6	5	-	1	-	-	-
Tubular adenomas	150	48	36	32	17	14	2	1	-
Tubulo-villous adenomas	47	2	7	12	6	13	2	2	3
Villous adenomas	8	-	2	2	1	1	-	1	1
Inflammatory polyps	3	-	-	1	1	1	-	-	-
Retention polyps	2	-	-	-	1	1	-	-	-
Miscellaneous polyps	23	12	6	-	2	2	-	-	1
Total	239	110	57	52	28	33	4	4	5

TABLE 5. Number, site and histologic nature of polyps removed

	Total	Rectum	Sigmoid colon	Descending colon	Left flexure	Transverse colon	Right flexure	Ascending colon	Caecum
Metaplastic polyps	60	50	7	1	-	2	-	-	-
Tubular adenomas	150	34	53	29	5	9	2	6	12
Tubulo-villous adenomas	47	22	14	5	2	2	-	-	2
Villous adenomas	8	7	-	-	-	-	-	1	-
Inflammatory polyps	3	1	1	-	-	-	1	-	-
Retention polyps	2	-	-	2	-	-	-	-	-
Miscellaneous polyps	23	2	3	3	3	2	-	8	2
Total	293	116	78	40	10	15	3	15	16

TABLE 6. Grade of histologic differentiation and number of various benign colorectal adenomas

	Total	Well	Moderate	Poor	Severe atypia	Suspect malignancy	Pseudo- carcino- matous invasion
Tubular adenomas	150	18	71	32	19	8	2
Tubulo-villous adenomas	47	-	16	15	13	3	-
Villous adenomas	8	-	-	4	3	1	-
Miscellaneous polyps	4	-	1	-	-	3	-
Total	209	18	88	51	35	15	2

are tabulated in Table 7. Of these lesions, 50 in 46 patients were verified at repeat DCE (Table 8 A), and another 30 polyps in 30 patients (Table 8 B) were seen in at least 3 roentgenograms of good quality. The remaining 29 lesions alleged at the index DCE in 28 patients were not verified. Their existence must be doubted for they were seen only in a few projections in patients not properly prepared for DCE. In 22 of these last patients, another polyp was proved or verified (Table 8).

In 20 patients, DCE revealed 23 rectal polyps (Table 7). In 14 patients neither rectoscopy nor repeated DCE studies were performed, mainly because of advanced age in 9, alcoholism in 3 and refusal to accept further examinations by 2. In 3 patients no rectal polyps could be seen at rectoscopy, and in 2 others the possibility of polyps was excluded (Table 2).

It is clear from the decision matrix /52, 53/ in Table 10 A that the sensitivity was 74.4 %, the specificity 99.7 % and accuracy 97.3 %. When, in addition, lesions reproducible in consecutive DCE studies and/or lesions seen in at least 3 high-quality roentgenograms obtained on the same occasion, were accepted as most likely, the number of patients with polyps diagnosed by DCE in this series was 229. The sensitivity then rose to 77.4 %, whereas the other parameters were essentially the same.

Discussion

To the question: "Is there any need to detect all colonic polyps?", the answer is "No". Ninety per cent of all polyps of the large intestine are metaplastic in origin, and they will remain so /28, 54, 55/. They tend to be multiple and are so tiny that they are easily overlooked even at sigmoidoscopy /55/. In our series only 20 % of examined polyps were metaplastic in origin.

The clinically important question whether there is any need to detect all adenomas has been answered in the affirmative. For, although the majority of adenomas will remain benign /43/, others will not. In other words, their removal is meant to be cancer prevention /13, 18, 19, 37/ (Fig. 1).

TABLE 7. Size, number and distribution within the large bowel of 109 polypoid lesions suspected at index DCE in 74 patients.

The size of the lesions (mm) measured in the roentgenograms

Segments of the large bowel	Total	S i z e o f p o l y p s , mm					
		0	4	5	8	10	15
		.	.	.	.	.	.
Rectum	23	14	6	3	-	-	
Sigmoid colon	25	6	9	7	2	1	
Descending colon	28	6	9	11	2	-	
Left flexure	10	2	3	5	-	-	
Transverse colon	11	5	2	3	1	-	
Right flexure	5	5	-	-	-	-	
Ascending colon	6	-	6	-	-	-	
Caecum	1	-	-	1	-	-	
Total	109	38	35	30	5	1	

TABLE 8. Polypoid lesions (n = 109) suspected at index DCE in 74 patients.
Lesions measured (mm) in the roentgenograms. Figures denote
numbered polyps in various parts of the bowel.

A. Lesions diagnosed on at least two consecutive DCE studies:
verified lesions (46 patients)

Segments of the large bowel	Total	S i z e o f p o l y p s , mm					
		0	4	5	8	10	15
		.	.	.	.	.	.
Rectum	4	2	1	1	-	-	
Sigmoid colon	9	2	3	3	-	1	
Descending colon	19	4	5	9	1	-	
Left flexure	7	2	2	3	-	-	
Transverse colon	6	2	1	2	1	-	
Right flexure	1	1	-	-	-	-	
Ascending colon	3	-	3	-	-	-	
Caecum	1	-	-	1	-	-	
Total	50	13	15	19	2	1	

TABLE 8. B. Lesions seen in at least three films: Lesions likely to be true polyps (20 patients)

Site	Total	S i z e o f p o l y p s , mm					
		0	4	5	8	10	15
		.	.	.	.	.	.
Rectum	8	7	-	1	-	-	-
Sigmoid colon	7	4	3	-	-	-	-
Descending colon	6	2	2	1	1	-	-
Left flexure	2	-	1	1	-	-	-
Transverse colon	3	3	-	-	-	-	-
Right flexure	3	3	-	-	-	-	-
Ascending colon	1	-	1	-	-	-	-
Total	30	19	7	3	1	-	-

TABLE 8. C. Lesions inconstantly seen: DCE false positive lesions

Site	Total	S i z e o f p o l y p s , mm					
		0	4	5	8	10	15
		.	.	.	.	.	.
Rectum	11	5	5	1	-	-	
Sigmoid colon	9	-	3	4	2	-	
Descending colon	3	-	2	1	-	-	
Left flexure	1	-	-	1	-	-	
Transverse colon	2	-	1	1	-	-	
Right flexure	1	1	-	-	-	-	
Ascending colon	2	-	2	-	-	-	
Total	29	6	13	8	2	-	

Owing to the outstanding results of colonoscopy in the detection and treatment of small lesions, the method tends to replace radiographic examination of the colon /15, 56/. This can be explained on the basis of the technique used in many radiological departments, namely a method based on contour diagnostics, when appropriate, combined with compression spot films /56, 57/. This technique is almost inadequate for revealing lesions less than 5 mm across and overlooks every second lesion up to 10 mm /58/.

Although the malignant potential of polyps is related to size, small adenomas consist of precursor tissue and are thus precancerous lesions /11, 17, 28, 54, 59/. The natural history of these tumours shows a mean linear growth rate of 0.61 mm/month, corresponding to an average time of 5.4 - 12 years /14, 28/ being required for the tumours to increase from 1 to 5 cm /10/. This slowness of growth offers an excellent opportunity for successful treatment provided the tumour is recognized in its precancerous, insidious phase /60, 61/. In order to document the proportion of missed lesions in this series, the follow-up study will be continued.

As early as 1931, attention was drawn to the possibility of demonstrating polypoid colorectal lesions with a special roentgenographic method, which is known as the double-contrast enema technique /32/. The potential diagnostic capacity of this method was later confirmed /33 - 36, 50, 51, 56/. The DCE technique proved capable of detecting even small polyps about 5 mm across, which in combination with colonoscopy meant that practically all such neoplasms could be detected and treated /14, 15, 28, 29, 50, 51/. Despite these advantages, DCE is still not used in many hospitals. We therefore thought it worthwhile to test the value of DCE for detecting polyps in a prospective study.

Opinions differ whether single or double-contrast enema is the radiographic method of choice in examining the large bowel /62 - 66/. No study has been presented comparing the diagnostic yield of these methods in the same patient, although different series have been compared /62, 66 - 68/.

In planning the present investigation, our aim was to perform such a comparison, but this was not feasible for ethical reasons. We therefore decided to compare the findings at the primary (index) DCE with those obtained from clinical, histopathologic and radiographic follow-up studies, if any, during an observation period of at least 40 months (mean 44). This follow-up period was too short

to permit disclosure of minor polypoid lesions primarily overlooked, but presumably was long enough to reveal any existing carcinoma. Because a colonoscopy in every patient could not be justified, the true number of polyps existing at the index DCE will remain unknown. On the other hand, a follow-up period that is too long would in the end reveal new polyps. The design of the present clinical series was thus a compromise and patients not further examined were considered to be free of major polyps.

The definition of the sensitivity of DCE in detecting polyps has been the subject of much debate /67, 68/. However, no prospective clinical series have presented a statistical analysis of the results of a follow-up survey of virtually unselected, consecutive patients, including those in whom the index examinations did not reveal anything abnormal /69/.

Patients accepted in our series were routinely referred for DCE, i.e. no screening procedure for large bowel diseases was in progress at our hospital. Although there were 12 % more women included (1,183 women and 935 men), there were 11 % more men with polypoid lesions of the large bowel (151 men and 120 women). In our investigation polyps were found in 10 % of the women (120 of 1,183) and in 16 % of the men (151 of 935). These findings are in good agreement with those reported in other series /17, 19, 70/. With all available means, a total of 271 patients were found to have polypoid lesions (12 %). Of patients with polyps, 253 were older than aged 45 years. The roentgenographic diagnosis of a polyp was based on the generally accepted geometrical features as described by Simpkins and Young /22/.

The distribution of polyps throughout the large bowel in this investigation was 66 % in the rectum and sigmoid colon and 34 % in the remaining colon. This pattern of distribution accords with other series /17, 19/. Further, 167 polyps (57 %) were 5 mm or less across, 60 (20 %) were metaplastic polyps and 150 lesions (50 %) were tubular adenomas (Tables 4 and 5). The proportion of the three histologic types of adenoma obtained in our study equals those reported in other series, and so was the true number of suspected malignant to benign polyps in the three groups of adenomas (Table 6) /14, 17, 19, 55, 59/.

In addition to the 293 polypoid lesions histopathologically examined, 109 were exclusively diagnosed at DCE (Fig. 2, Table 7). Of these, 50 were verified at

subsequent DCE (Table 8 A) but not removed. Another 59 polyps were not followed up (Tables 8 B and C). At review of the corresponding index roentgenograms, 30 polyps were seen at the same site in at least 3 different projections, including one cross-table beam film of good quality. These lesions were thus considered probable true polyps (Table 8 B). At the retrospective review, the remaining 29 DCE-alleged polyps did not satisfy these criteria and were thus considered as false positive diagnoses (Table 8 C).

The sizes of these 109 polyps are presented as the smallest diameter seen in the roentgenograms, i.e. no correction was made for the geometrical magnification. In spite of this, only 6 of them were more than 8 mm across and were found in old patients. This explains why 107 of these polyps had neither been removed nor excluded.

At review of the 71 index DCE studies with missed lesions, the polyps had been overlooked owing to inferior quality of the roentgenograms or, in 29 cases owing to reduced co-operation by the patients. Besides, 23 patients were at least 75 years of age. In the remaining patients, as well as in the other 22 with both diagnosed and overlooked additional polyps (Table 3), the growths were disclosed in retrospect in 14, but still not seen in 12 patients in spite of a good DCE technique.

The total number of patients with proved polyps was 9.4 %, i.e. 199 to the total 2,118 patients. Including 66 patients with DCE verified or likely to be true polyps (Tables 8 A and B), the proportion increased to 12.5 %.

In the same clinical series of 2,590 patients, 127 benign polyps were found in 31 patients with colorectal cancer. Of these polyps, 38 were found at DCE in 15 patients /73/. Including these patients the total number of patients with polyps increased to 296 out of 2,217 patients ($n = 2,118 + 99$), i.e. in 13 %, corresponding to the prevalence of polyps found in this population post-mortem /10, 17/. According to Tables 10 A and B, the probability of a patient with a positive DCE diagnosis of polyps actually having such a lesion in the large intestine and that of a patient in whom the DCE study had not shown anything abnormal being free from such a lesion was high. This shows that the routine DCE method is reliable in detecting and excluding patients with these lesions.

TABLE 9. Removed polyps demonstrated by follow-up DCE (n = 45) and by endoscopy (n = 50), and their size (mm) measured after removal. Figures denote number of polyps at various sites in the bowel (n = 71 patients)

Site	Total	S i z e o f p o l y p s , mm					
		0	4	5	8	10	15
		.	.	.	.	.	.
Rectum	42	32	4	2	1	3	
Sigmoid colon	16	8	3	4	1	-	
Descending colon	9	5	3	-	-	1	
Left flexure	2	-	1	1	-	-	
Transverse colon	6	2	3	1	-	-	
Right flexure	1	-	1	-	-	-	
Ascending colon	11	9	2	-	-	-	
Caecum	8	4	2	1	1	-	
Total	95	60	19	9	3	4	

TABLE 10. Number of patients with proved polypoid lesions and absence of such lesions during 40 months follow-up. Figures denote number of patients with a positive or negative index DCE for large bowel polyps.
A. Patients with proved polyps in the polyp series

Index DCE	P a t i e n t s		
	with proved polyps	without polyps	Total
Positive	148	6	154
Negative	51	1913	1964
Total	199	1919	2118

Sensitivity $148/199 = 0.744$

Specificity $1913/1919 = 0.997$

Accuracy $(148 + 1913)/2118 = 0.973$

Predictive value of a positive DCE: $148/154 = 0.961$

Predictive value of a negative DCE: $1913/1964 = 0.974$

TABLE 10. B. Patients with proved, verified and likely polyps in the extended series including those with colorectal carcinoma

Index DCE	Patients with polyps		
	proved, verified or likely polyps	undisclosed polyps during follow-up	Total
Positive	229	6	235
Negative	67	1915	1982
Total	296	1921	2217

Sensitivity: 0.774

Specificity: 0.997

Accuracy: 0.970

Predictive value of a positive DCE: 0.975

Predictive value of a negative DCE: 0.966

The total number of polyps (proved, verified and likely), diagnosed in the extended series of 2,217 patients, i.e. patients with colorectal carcinomas included, was 500 ($n = 293 + 127$ histologically examined + 80 verified or as likely true polyps at index DCE) in 296 patients ($n = 271 - 6 + 31$). This corresponds to 1.7 polyps /patient with polyps, a figure that accords with other series /72/. Of these polyps, 316 were diagnosed at DCE ($n = 198 + 38$ proved + 80 verified or likely true polyps), which gives a sensitivity for DCE in polyp detection of 63 % and the predictive value of a positive DCE report 92 %. This means that 37 polyps of 100 were overlooked and that a DCE must be repeated or be combined with colonoscopy if every polypoid lesion of the colon is to be detected, especially in patients with synchronous carcinoma. We found that 93 % of polyps overlooked at DCE were less than 9 mm across and that 83 % were small, up to 5 mm (Table 9), a result in agreement with others /68/. The same was true also for the false positive diagnosis: only 7 %, 2 out of 29, of these were more than 8 mm across (Table 8 C).

Conclusions

Roentgenography with an adequate double-contrast enema technique is reliable for detecting and excluding patients with polypoid lesions of the large bowel. However, detection of every single lesion requires the examination to be re-read and supplemented with colonoscopy.

Acknowledgement

This work was supported by the Swedish Medical Research Council, Project No. B79-29X-4819-04.

References

1. Dukes C: Simple tumors of the large intestine and their relation to cancer. Brit J Surg 13:720-733, 1925
2. Fitzgibbon G, Rankin FW: Polyps of the large intestine. Surg Gynecol Obstet 52:1136-1150, 1931
3. Swinton NW, Shields W: Polyps of the colon and rectum and their relation to malignancy. JAMA 113:1927-1933, 1939
4. Swinton NW, Haug AD: The frequency of precancerous lesions in the rectum and colon. Lahey Clin Bull 5:84-88, 1947
5. Hultborn KA: The causal relationship between benign epithelial tumors and adenocarcinoma of the colon and rectum. Acta Radiol Suppl 113, 1954
6. Grinell RS, Lane N: Benign and malignant adenomatous polyps and papillary adenomas of the colon and rectum. An analysis of 1856 tumors in 1335 patients. Int Abstr Surg 106:519-538, 1958
7. Helwig EB: Adenomas and the pathogenesis of cancer of the colon and rectum. Dis Col Rect 2:5-17, 1959
8. Andrén L, Frieberg S: Frequency of polyps of rectum and colon, according to age and relation to cancer. Gastroenterology 36:631-632, 1959
9. Fitts WT: Adenomas of the colon and rectum. Amer J Surg 101:87-90, 1961
10. Ekelund G: On cancer and polyps of colon and rectum. Acta Path Microbiol Scand 59:165-170, 1963
11. Ekelund G, Lindström C: Histopathological analysis of benign polyps in patients with carcinoma of the colon and rectum. Gut 15:654-663, 1974
12. Ekelund G, Lindström C, Rosengren J-E: Appearance and growth of early carcinomas of the colon-rectum. Acta Radiol 15:670-679, 1974
13. Gilbertsen VA: Proctosigmoidoscopy and polypectomy in reducing the incidence of rectal cancer. Cancer 34:936-939, 1974
14. Morson BC: The polyp-cancer sequence in the large bowel. Proc Soc Med 67:451-457, 1974
15. Jackson BR: Adenoma of the colon and rectum: Histopathology and management. Dis Col Rect 17:656-667, 1974
16. Wilson GL, Dale EH, Brines OA: An evaluation of polyps detected in 20,847 routine sigmoidoscopic examinations. Amer J Surg 90:834-840, 1955
17. Berge T, Ekelund G, Mellner C, Pihl B, Wenckert A: Carcinoma of the colon and rectum in a defined population. Acta Chir Scand Suppl 438, 1973

18. Rosensweig J, Howitz A: Adenomatous tumors of the colon and rectum: the importance of early detection and treatment. Amer Surg 24:515-520, 1958
19. Engquist IF, State D: Rectal and colonic polyps. Surgery 32:696-703, 1952
20. Hertz REL, Deddish MR, Day E: Value of periodic examination in detecting cancer of the rectum and colon. Postgrad Med 27:290-294, 1960
21. Engquist IF: The incidence and significance of polyps of the colon and rectum. Surgery 42:681-688, 1957
22. Simpkins KE, Young AC: The radiology of colonic and rectal polyps. Brit J Surg 55:731-735, 1968
23. Hildell J, Rosengren J-E: Double contrast examination in disease of the anorectal region. Radiologe 15:434-441, 1975
24. Frühmorgen P, Demling L: Complications of diagnostic and therapeutic colonoscopy in the Federal Republic of Germany. Results of an inquiry. Endoscopy 11:146-150, 1979
25. Thoeni RF, Menuck L: Comparison of barium enema and colonoscopy in the detection of small colonic polyps. Radiology 124:631-635, 1977
26. Miller RE, Lehman G: Polypoid colonic lesions undetected by endoscopy. Radiology 129:295-297, 1978
27. Leinicke JL, Dodds WJ, Hogan WJ, Stewart ET: A comparison of colonoscopy and roentgenography for detecting polypoid lesions of the colon. Gastrointest Radiol 2:125-128, 1977
28. Morson BC: Genesis of colorectal cancer. Clin in Gastroenterology 5: 505-525, 1976
29. Shinya H, Wolff W, DeBeer R, Geffen A: Radiographic and colonoscopic diagnosis of colon and rectal pathology - an adjunctive and comparative analysis of five-hundred cases. Abstract. Gastroenterology 66:825, 1974
30. Fischer AW: Über eine neue röntgenologische Untersuchungsmethode des Dickdarms: Kombination von Kontrasteinlauf und Luftaufblähung. Klin Wchnschr 2:1595-1598, 1923
31. Fischer AW: Über die Röntgenuntersuchung des Dickdarms mit Hilfe einer Kombination von Lufteinblasung und Kontrasteinlauf. Langenbecks Arch Chir 134:209-269, 1925
32. Weber HM: Roentgenologic demonstration of polypoid lesions and polyposis of the large intestine. AJR 25:577-589, 1931
33. Welin S: Modern trends in diagnostic roentgenology of the colon. Brit J Radiol 31:453-464, 1958

34. Welin S: Über moderne röntgenologische Dickdarmsdiagnostik unter besonderer Berücksichtigung der Doppelkontrastmethode. Munch Med Wchnschr 100:1142-1144, 1958
35. Hettler M: Zur Technik der Doppelkontrastdarstellung des Dickdarms. Radiologe 2:115-124, 1962
36. Miller RE: Die vollständige Colonuntersuchung. Radiologe 15:410-420, 1975
37. Andrén L, Frieberg S, Welin S: Roentgen diagnosis of small polyps in the colon and rectum. Acta Radiol 43:201-208, 1955
38. Welin S: Results of the Malmö technique of colon examination. JAMA 199:369-371, 1967
39. Ott DJ, Gelfand DW: Colorectal tumors: pathology and detection. AJR 131:691-695, 1978
40. Laufer I, Smith NOW, Mullens JE: The radiological demonstration of colorectal polyps undetected by endoscopy. Gastroenterology 70:167-170, 1976
41. Welin S: Results of the Malmö technique of colon examination. JAMA 199:119-121, 1967
42. Maruyama M, Sugiyama N, Funada A, Sasaki T, Takekoshi T, Ujiie K, Kumakura YBK, Kurohawa T: Double contrast radiography of the colon and rectum by means of the universal gyroscopic x-ray television apparatus. Nippon Acta Radiol 33:786-798, 1976
43. Buntain WL, ReMine WH, Farrow GM: Premalignancy of polyps of the colon. Surg Gynecol Obstet 134:499-508, 1972
44. Leffall LD, Chung EB: Surgical management of colorectal polyps. Cancer 34:940-947, 1974
45. Wolff WI, Shinya H: Colonofiberscopic management of colonic polyps. Dis Col Rect 16:87-93, 1973
46. Williams CB, Hunt RH, Loose H, Riddell RH, Sakai Y, Swarbrick ET: Colonoscopy in the management of colon polyps. Brit J Surg 61:673-682, 1974
47. Christie JP, Shinya H: Indications for fiberoptic colonoscopy. South Med J 68:881-886, 1975
48. Brown GR: A new approach to colon preparation for barium enema: a preliminary report. Univ Mich Med Bull 27:225-230, 1961
49. Fork F-T, Ekberg O, Nilsson G, Rerup C, Skinhøj A: Colon cleansing regimens - a clinical study in 1,200 patients. Gastrointest Radiol 1982 (in press)

50. Fork F-T: Resultatvergleich zwischen der Doppelkontrastuntersuchung des Dickdarms und der Koloskopie mit Biopsie. In: Die Doppelkontrastuntersuchung des Dickdarms. Ed Welin S and Welin G, Georg Thieme, Stuttgart, N.Y., 1980
51. Fork F-T: Double contrast enema and colonoscopy in polyp detection. Gut 22:971-977, 1981
52. Lusted LB: Decision-making studies in patient management. New Engl J Med 284:416-424, 1971
53. Galen RS, Gambino SR: Beyond Normality: The Predictive Value and Efficiency of Medical Diagnoses. John Wiley and Sons, N.Y., 1975
54. Lane N, Fenoglio M: The adenoma-carcinoma sequence in the stomach and colon. Gastrointest Radiol 1:111-119, 1976
55. Ekelund GR: Cancer Risk with Single and Multiple Adenomas: Synchronous and Metachronous Tumors. In: Colorectal Cancer: Prevention, Epidemiology and Screening. Ed Winawer S, Schottenfield D, Sherlock P., Raven Press, N.Y., 151-155, 1980
56. Dodd GD: The radiological diagnosis of carcinoma of the colon. In: Gastrointestinal Cancer. Ed Stroehlein JR and Romsdahl MM., Raven Press, N.Y., 1981
57. Figiel LS, Figiel SJ, Hennessey A: Carcinoma of the colon. Incidence of error in the roentgen diagnosis. Amer J Gastroenterol 40:487-503, 1963
58. Gelfand DW, Ott DJ: Single - vs. double-contrast gastrointestinal studies: critical analysis of reported statistics. AJR 137:523-528, 1981
59. Enterline HT: Polyps and cancer of the large bowel. In: Current Topics in Pathology. Ed Morson BC., 63:95-140, 1976
60. Figiel LS, Figiel SJ, Wietersen FK: Is surgical removal of every colonic polyp necessary? AJR 88:721-732, 1962
61. Dukes CD: Pre-cancerous conditions of the colon and rectum. J Roy Coll Surg Edinburgh 3:182-192, 1958
62. Marshak RH, Lindner AE: Granulomatous colitis. In: Seminars in Roentgenology 3:27-61, 1968
63. Gianturco C: High-voltage technique in the diagnosis of polypoid growths of the colon. Radiology 55:27-29, 1950
64. Figiel LS, Figiel SJ, Rush DK: Study of colon by use of high-voltage spot-compression technique. JAMA 166:1269-1274, 1958
65. Miller RE, Brahme F: The clarity of good technic. Amer J Dig Dis 12:418-420, 1967

66. Miller RE: Detection of colon carcinoma and the barium enema. JAMA 230: 1195-1198, 1974
67. Ott DJ, Gelfand DW, Wu WC, Kerr RM: Sensitivity of double-contrast barium enema: Emphasis on polyp detection. AJR 135:327-330, 1980
68. Williams C: Evaluation of the colonoscopic examination: Results of three studies. Dis Col Rect 18:366-368, 1975
69. Brahme F, Ekelund GR, Nordén JG, Wenckert A: Metachronous colorectal polyps. Dis Col Rect 17:166-171, 1974
70. Granqvist S, Gabrielsson N, Sundelin B: Diminutive colonic polyps - clinical significance and management. Endoscopy 1:36-42, 1979
71. Welin S: Röntgendiagnostik der Dickdarmpolypen. In: Encyclopedia of Medical Radiology, Ed Diethelm L, Olsson O, Strand F, Vieten H, Zuppingen A., Springer, Berlin, Heidelberg, N.Y., XI/2, 404-448, 1968
72. DeBeer RA, Geffin A, Ozoktay S, Shinya H, Wolff WI: Comparison of colonoscopy and contrast x-ray study in diagnosis of 500 cases of colorectal disease. J Amer Osteopath Ass 75:569-574, 1976
73. Fork F-T, Ekelund GR, Lindström C: The double-contrast enema in carcinoma of the colon and rectum. Acta Radiol Diagnosis 1982 (in press)

From the Departments of Diagnostic Radiology, Pathology and Surgery,
Malmö Allmänna Sjukhus, S-214 01 Malmö, Sweden

THE DOUBLE-CONTRAST EXAMINATION IN CARCINOMA
OF THE COLON AND RECTUM

A prospective clinical study

FRANS-THOMAS FORK, CLAS LINDSTRÖM and GÖRAN EKELUND

It has been shown that only 25 per cent of all persons with colorectal carcinoma are cured today (BERGE et coll. 1973). The prognosis varies with the extent of carcinomatous infiltration of the bowel wall. Thus, the 5-year corrected survival for patients with colonic cancer, stage Dukes' A, is close to 100 per cent and for rectal cancer about 75 per cent, compared with 45 per cent in stage Dukes' C for colonic and 30 per cent for rectal cancer (BERGE et coll. 1973). It has also been shown that 90 per cent of all patients with asymptomatic carcinoma of the rectum detected by proctoscopy and treated surgically were still alive 15 years after operation (WINAWER et coll. 1976). Thus, it seems important to detect malignant lesions as early as possible. Cumulative, strong evidence clearly suggests that cancer is prone to develop from polyps (Fig. 1) (EKELUND 1974, LINDSTRÖM et coll. 1978, MORSON 1974 a). It is now generally recognized that the double-contrast examination of the large bowel - henceforth to be referred to as DCE - is very useful for detecting small mucosal lesions, e.g. polyps. But, although this method has been used routinely at our department since 1953 (WELIN 1958, 1967) and has detected large and/or growing polyps that have been removed surgically, patients still present with advanced lesions (Figs. 2 and 3). In an attempt to assess the diagnostic capacity of the DCE in colorectal carcinoma, this prospective study was initiated.

Material and methods

During a 9-month period, beginning in May 1976, 2590 consecutively examined patients were included in a prospective series to assess the accuracy of DCE. The patients were followed up radiographically with clinical observations, colonoscopy and tissue examinations at the pathological department until June 1980.

All DCE's, colonoscopies and autopsies in patients included in this series performed during the follow-up period were recorded. If a patient had a positive DCE, the records were looked through and reports from rectoscopies and operations were collected, as were all pathological reports from these and from autopsies, if any. The results from the rectoscopy and the following pathological reports were also collected from all patients with an abnormal finding at recto-



Fig. 1. A 105-mm stricturing carcinoma of the right flexure in a patient with 6 benign polyps detected at the same DCE. Arrows indicate 5 of these .



Fig. 2. A 22-mm large carcinoma in the sigmoid colon from a tubulovillous adenoma.



Fig. 3. A 55-mm large stricturing carcinoma of the sigmoid colon. Two polyps were found in the specimen in the vicinity of the carcinoma.

scopy and a DCE showing nothing abnormal. A case in which a primary DCE (index DCE) in this series had been reported as normal and in which a colorectal carcinoma was discovered within the follow-up period was classified as a DCE error. These patients could easily be found because there is only one hospital in Malmö where patients with this disease are treated.

Of the 2590 patients, 55 had been examined with a single barium examination and were therefore excluded. The remaining 2535 patients were examined with DCE (FISCHER 1923, SHAY & GERSHON-COHEN 1934, WEBER 1931, 1933, WELIN 1958, 1967).

Routinely, a DCE is interpreted by an experienced radiologist who also provides a written report. The examination is then demonstrated for the clinician by another radiologist. During the first 3 months of this series, all the roentgenograms were, in addition, independently reviewed by two other experienced radiologists who were unaware of previous clinical and radiographic reports. Thereafter, only one (F-T F) read the roentgenograms. If the results of these examinations differed from those of the preliminary report, the clinician in charge of the patient was informed by letter. Thus, at least three radiologists had seen all the roentgenograms.

The tumours were surgically removed in 84 patients and were studied post mortem in 19 others. The tumours were all examined histologically by one pathologist (CL) with respect to the nature of the actual tumour, local metastasis and any coexisting neoplasia.

Results

The clinical DCE series consisted of 2535 patients, 103 of whom were found to have malignant, in situ, or infiltrating lesions of the large bowel: 53 of the latter were women, aged 32 to 90 years (mean 70), and 50 were men, aged 50 to 87 years (mean 69.2). Ninety-nine carcinomas were found - a single carcinoma in 93 patients and two in 3 (Table 1). In 7 patients malignant lesions other than colorectal adenocarcinoma were diagnosed: viz. a caecal carcinoid (1); gastric carcinoma involving the transverse colon (2); peritoneal carcinosis

		Men	Women
Sites	Totals		
	102	49	53
Rectum	32	16	16
Sigmoid colon	32	11	21
Descending colon	5	4	1
Left flexure	4	2	2
Transverse colon	4	2	2
Ascending colon	8	4	4
Caecum	17	10	7
Age distribution		50-87	32-90
Mean age		69.2	70.0

TABLE 1. Age and sex distribution of 102 patients with malignant lesions of the large bowel. Figures denote various sites of the main lesions (one man, aged 62 years, with colonic lymphoma not included)

(1); ovarian carcinoma involving the sigmoid colon (1); malignant intestinal lymphoma (1) (Fig. 4); and a cloacogenic, squamous cell anal carcinoma extending into the rectum (1).

The distribution of all malignant lesions is shown in Figure 5. Sixty-five of the 99 adenocarcinomas were found in the rectum and sigmoid colon, 10 in the remaining left hemicolon and 24 in the right hemicolon. Eighteen tumours were less than 30 mm across (Table 2), and 14 exceeded 80 mm. Most of the former tumours were found in the rectum and sigmoid colon, whereas the larger ones were uniformly distributed along the entire large bowel.

Most carcinomas arising from tubular adenomas were small, whereas all other types varied widely in size (Table 2). Ninety-one carcinomas, including also 4 of 9 tumours less than 21 mm across, had infiltrated deeply into the bowel wall. At operation two specimens with small tumours, 20 and 30 mm across, exhibited metastases in regional, mesenteric lymph nodes. Otherwise, practically every second carcinoma, regardless of size, displayed regional metastases (Table 2).

Half of the carcinomas were ulcerating ones, and 16 per cent were polypoid, 16 per cent stricturing, and 15 per cent apparently originated from tubulo-villous or villous adenomas (Tables 3, 4). All of these types were uniformly distributed throughout the large bowel (Table 3). This was also true of the well-differentiated carcinomas and of tumour with regional metastases. Six out of 7 tumours infiltrating the bowel wall not beyond the submucosa (early carcinoma) were situated in the rectum and sigmoid colon. None of these manifested regional lymph node metastases.

Most malignant tumours arising from either tubular ($n = 5$) or tubulo-villous and villous ($n = 15$) adenomas were well differentiated (Table 4). However, 12 out of 20 had infiltrated deeply into the bowel wall: into or beyond the submucous layer. Two-thirds (29 of 47) of the tissue specimens of ulcerating carcinomas were obtained from patients that had metastases to the regional lymph nodes and 86 per cent (19 of 22) of tissue specimens with poorly differentiated tumours revealed such metastases.

In 31 specimens from 96 patients with colorectal cancer, 127 benign polyps were found (Fig. 1, Table 5 a). Of these, 76 (almost two-thirds) were tubular



Fig. 4. Gastro-intestinal lymphoma with polypoid masses in the left hemicolon and cauliflower-like masses in the right hemicolon

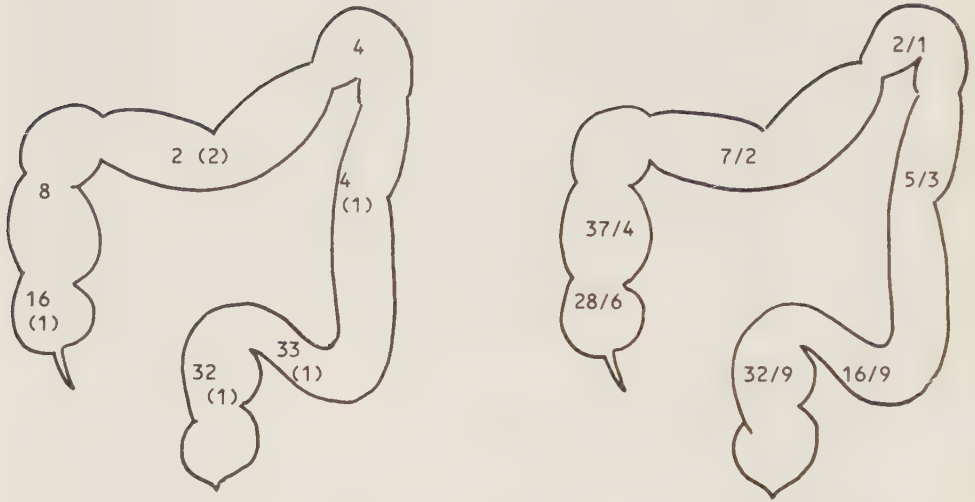


Fig. 5. The distribution of malignant lesions throughout the large bowel.

a/ Figures in parentheses denote other malignant lesion than adenocarcinoma coli. 105 malignant lesions in 102 patients. One patient had intestinal lymphoma

b/ Coexisting benign polyps in number of patients. 127 polyps in 31 patients

	Total		TUMOUR SIZE, mm					
		10-20	21-30	31-40	41-60	61-80	81-100	101-
TOTAL	99	9	9	25	25	17	7	7
SITE								
Rectum	32	5	2	7	10	7	1	
Sigmoid colon	33	2	5	10	7	5	3	1
Descending colon	4	1	1			1	1	
Left flexure	4	1		1				2
Transverse colon	2		1		1			
Right flexure and ascending colon	8			2	4	1		1
Caecum	16			5	3	3	2	3
TYPE								
From tubular adenoma	5	3	1		1			
From tubulovillous or villous adenoma	15	1	3	5	2	3	1	
Ulcerating carcinoma	47	2	2	13	13	10	3	4
Polypoid carcinoma	16	2		4	4	2	2	2
Strictureing carcinoma	16	1	3	3	5	2	1	1
GRADE OF DIFFERENTIATION								
Well	34	7	4	8	8	3	1	3
Moderate	37	2	4	9	10	10	2	
Poor	22			7	5	3	4	3
Not specified	6		1	1	2	1		1
DEPTH OF INFILTRATION								
In situ	6	3		1	2			
Lamina propria	1	1						
Muscularis mucosa	1	1						
Submucosa	6		4	1	1			
Muscularis propria	4			2	1		1	
Subserosa	37	2	3	8	9	9	3	3
Through the serosa	43	2	2	12 ^{x/}	12	8	3	4
METASTASES IN REGIONAL LYMPH NODES	45	1	1	10	14	9	6	4

x/ One tumour not specified.

TABLE 2. Size, location and histologic classification of the carcinomas

LOCALIZATION

	Total	Rectum	Sigmoid colon	Descend- ing colon	Left flexure	Trans- verse colon	Ascend- ing colon	Caecum
TOTAL	99	32	33	4	4	2	8	16
TYPE								
From tubular adenoma	5	1	3	1				
From tubulo-villous or villous carcinoma	15	6	5	1				
Ulcerating carcinoma	47	19	14		2	1	1	2
Polypoid carcinoma	16	4	3	1	1		5	6
Stricturing carcinoma	16	2	8	1	1	1	2	7
								1
DEPTH OF INFILTRATION								
In situ	6 ^x /	3	2	1				
Lamina propria	1	1						
Muscularis mucosa	1		1					
Submucosa	6	1	2	1			2	
Muscularis propria	4	2	1					
Subserosa	37	10	11	1	2	2	5	1
Through the serosa	43	14	16	1	2		1	6
								9
METASTASES IN REGIONAL LYMPH NODES								
	45	15	13	1	3		4	9

x/ One lesion not specified

TABLE 3. Histologic classification and site of carcinomas, their degree of infiltration and the existence of regional metastases

	Total	From tubular adenoma	From villous adenoma or tubulo- villous adenoma	Ulcerating carcinoma	Polypoid carcinoma	Stricturing carcinoma	Metastases in regional lymph nodes
TOTAL	99	5	15	47	16	16	45
GRADE OF DIFFERENTIATION							
Well	34	4	11	10	4	5	9
Moderate	37	1	3	23	6	4	15
Poor	22			12	6	4	19
Not specified	6		1	2		3	2
DEPTH OF INFILTRATION							
In situ	6	3	3 ^x /				
Lamina propria	1				1		
Muscularis mucosa	1	1					
Submucosa	6	1	4			1	
Muscularis propria	4		3	1			2
Subserosa	37		4	18	8	7	15
Through the serosa	43			28	7	8	28
METASTASES IN REGIONAL LYMPH NODES	45		1	29	8	7	45

x/ One tumour not specified

TABLE 4. The differentiation and degree of infiltration according to the type of carcinoma and number of resected specimens with regional lymph node metastases

	Total	Meta- plastic	Tubular adeno- ma	Villous or tubulo- villous adeno- ma	Inflamma- tory	Miscel- laneous
TOTAL	127	40	76	5	4	2
LOCALIZATION						
Rectum	32	26	5			1
Sigmoid colon	16	5	8	3		
Descending colon	5		4			1
Left flexure	2		2			
Transverse colon	7	5	1	1		
Ascending colon	37	4	32		1	
Caecum	28		24	1	3	
Number seen at DCE	38	9	23	4	2	

TABLE 5 a. Histologic classification and location of 127 benign polyps in 31 patients with colorectal carcinoma and the number of polyps demonstrated at DCE

adenomas and 40 (one-third) metaplastic polyps. Half of the polyps ($n = 28+37$) were situated in the right hemicolon and 48 ($32 + 16$) in the rectum and sigmoid colon. Thirty-one of the latter were metaplastic. The DCE had revealed 38 of these polypoid lesions in 15 patients.

A total of 90 polyps were up to 5 mm in diameter. Of these, only 5 were diagnosed at DCE. Of the 12 polyps larger than 10 mm across, 9 were disclosed at DCE (Table 5 b).

Six carcinomas were missed by DCE, one in the rectum and 5 in the sigmoid colon. The former was a recurrent carcinoma after surgical removal of a cancer of the sigmoid colon 3 years earlier. Two carcinomas of the sigmoid colon were overlooked, one in a patient with a coexisting rectal carcinoma. The remaining 3 carcinomas were interpreted as diverticular lesions only (Table 6 a).

Five other tumours were primarily diagnosed (index DCE) as polyps - 4 of which were carcinomas 15 to 22 mm across and one a caecal carcinoid, 35 mm in diameter (Table 6 b). Moreover, 8 benign lesions in 5 patients were misinterpreted as carcinomas: viz. 5 tubulo-villous adenomas and 3 clustered tubular adenomas (Table 7). These polypoid lesions were revealed to be benign at rectoscopy and operation. In one patient the descending colon was deformed as a result of irradiation of a renal carcinoma. In the remaining patient, previously operated for carcinoma of the ascending colon, the DCE disclosed bulging masses around the anastomosis, which were interpreted as recurrent carcinoma. At re-operation the anastomosis was found to be free of carcinoma; a recurrence was, however, discovered in the surrounding tissue (Table 7).

Table 8 summarizes the lesions misinterpreted at DCE. Of 10 carcinomas 3 were totally overlooked, whereas 4 were diagnosed as polyps and 3 as lesions caused by diverticulitis. In one patient, a male, aged 75, with diverticular changes at DCE, the correct diagnosis was delayed for 3 months. At post-mortem examination the true nature of the lesion was revealed. There was no diagnostic delay in any other patient because endoscopy and/or bowel surgery was initiated on the basis of the DCE findings (Tables 6 a and b). Thus, in 6 instances the DCEs were totally false negative and in 2 false positive (Table 8), i.e. an irradiation deformity in one patient and normal anastomosis in another.

	Total	SIZE, mm			
		≤ 5	-10	-20	> 20
	127	90	25	9	3
Histologic type of polyp					
Metaplastic	40	31	9		
Tubular adenoma	76	59	13	3	1
Tubulo-villous adenoma	5		1	3	1
Inflammatory	5		2	2	1
Miscellaneous	1			1	
Number of polyps seen at DCE	38	5	24	7	2

TABLE 5 b. Histologic classification and size of 127 benign polyps in 31 patients with colorectal carcinoma and the number of polyps demonstrated at DCE

Sex	Age	Tumour size (mm)	Site	Type of carcinoma	Regional metastases	DCE diagnosis	Diagnostic procedure
M	67	10	Rectum	Ulcerating	-	Normal anastomosis	Operation
F	70	30	Sigmoid colon	Ulcerating	+	Rectal carcinoma	Operation
F	74	40	Sigmoid colon	Ulcerating	+	Diverticulitis	Operation
F	85	70	Sigmoid colon	Ulcerating	-	Diverticulitis	Operation
M	75	80	Sigmoid colon	Strictureing	+	Diverticula	Autopsy
M	55	20 ^x /	Sigmoid colon	From a tubular adenoma	-	Overlooked	Colonoscopy

x/ "Early" carcinoma

TABLE 6 a. Carcinomas not diagnosed as such at DCE (n = 6)

Sex	Age	Tumour size (mm)	Site	Type of carcinoma	Regional metastases	DCE diagnosis	Diagnostic procedure
F	60	15 ^x /	Rectum	From a tubulovillous adenoma	-	Benign polyp	Rectoscopy
M	73	20 ^x /	Rectum	From a tubulovillous adenoma	-	Benign polyp	Rectoscopy
F	62	22 ^x /	Sigmoid colon	From a tubulovillous adenoma	-	Benign polyp	Colonoscopy
M	67	15	Sigmoid colon	From a tubular adenoma	-	Benign polyp	Colonoscopy
M	54	35	Caecum	Carcinoid	-	Benign polyp	Operation
x/ "Early" carcinoma							

TABLE 6 b. Carcinomas interpreted as benign polyps (n = 5)

Sex	Age	Tumour size (mm)	Site	Type of lesion	Diagnostic procedure
F	71	10	Rectum	Tubulo-villous adenoma	Operation/Rectoscopy
M	78	23	Rectum	Tubulo-villous adenoma	Operation
M	69	35	Rectum	Tubulo-villous adenoma	Operation
F	74	35	Rectum	Tubulo-villous adenoma	Operation
F	76	45	Rectum	Tubulo-villous adenoma and three tubular adenomas	Operation
F	60	70	Descending colon	Post-radiological deformity	Autopsy
F	67	60	Transverse colon	Normal ileocolic anastomosis	Operation
M	69	35	Caecum	Villous adenoma	Operation

TABLE 7. Benign lesions interpreted as large-bowel carcinoma at DCE

		Radiographic diagnosis				
		Normal	Diverti- culitis	Poly- poid lesion	Colonic carci- noma	Miscel- laneous
	Total					
Histologic diagnosis	24	1	3	5	13	2
"Early" carcinoma	4	1		3		
Advanced carcinoma	6		3	1		2
Carcinoid	1			1		
Carcinoma of other origin:						
Gastric	2				2	
Ovarian	1				1	
Anal	1				1	
Peritoneal metas- tases	1				1	
Tubulo-villous adenoma	5				5	
Villous adenoma	1				1	
Post-radiological deformity	1				1	
Normal anastomosis	1				1	

TABLE 8. The histologic nature of lesions misjudged at DCE. Figures denote number of lesions

Errors were due to poor technique and to individual lapses in 5 patients, but were unavoidable in 3 patients with diverticulitis.

In the remaining 2424 patients, no colorectal carcinomas were diagnosed during the follow-up period (Table 9).

Of the 103 patients with malignant changes of the colon and rectum, 93 of the lesions were detected and recognized as malignant at DCE. In 8 other patients with benign polyps, carcinomas were falsely diagnosed at DCE. Placing these figures into a decision matrix facilitates the calculation of statistical parameters explaining the clinical value of the DCE in patients with carcinoma. Thus, the sensitivity was 90.3 per cent, the specificity 99.7 per cent, the accuracy 99.3 per cent, the predictive value of a positive DCE 92.1 per cent and that of a negative DCE 99.6 per cent (Table 9).

Discussion

Colorectal tumours producing symptoms are gross lesions and should thus easily be detected by radiography of the colon, for these tumours cause strictures and deformities of the loops (COOLEY et coll. 1960). However, since early lesions imply small size, their disclosure requires a radiographic technique capable of reproducing the mucous membrane even en face (MILLER 1974). The aim of our study was primarily to compare the conventional barium enema procedure with that of double-contrast roentgenography in the same patient, but this modality was not acceptable for ethical reasons. Therefore, we decided to compare the findings at DCE with those reported from clinical, histopathologic, and repeated radiographic examinations, during an observation period of at least 40 months. We anticipated that any carcinoma present but not diagnosed at the first, index DCE would be revealed during this follow-up period.

The average annual incidence of colorectal cancer in Malmö, 1958 - 1967, was 52 per 100 000; and when diagnosed intra vitam, 40 per 100 000, according to BERGE et coll. (1973). The expected number of carcinomas in this series would thus have been $40 \text{ per } 100\,000 \times 9/12 \times 233\,000$, i.e. 70 carcinomas. How-

Index DCE	Patients		Total
	with carcinoma	without carcinoma	
Positive	93	8	101
Negative	10	2424	2434
Total	103	2432	2535

The sensitivity of DCE: $93/103$: 0.903

The specificity of DCE: $2424/2432$: 0.997

The accuracy of DCE: $(93 + 2424)/2535$: 0.993

The predictive value of a positive DCE: 0.921

The predictive value of a negative DCE: 0.996

TABLE 9. The clinical value and efficiency of DCE in malignancy of the colon and rectum. Figures denote the number of patients

ever, 98 carcinomas of the colon and rectum were found, suggesting a considerable increase (1 carcinoma in 1 patient was diagnosed at autopsy). Of the additionally diagnosed 28 carcinomas, 21 were detected at DCE (75%), as this method was not biased by information from clinical or previous laboratory results. The high incidence in our study is in total agreement with the increased incidence of cancer of the large bowel, recently documented in the population of southern Sweden (National Bureau of Statistics 1976, Swedish National Board of Health and Welfare 1977). However, greater vigilance by clinicians, roentgenologists and pathologists may also, to some extent, explain the high number of cancers diagnosed *intra vitam*. Such an explanation is supported by the observation that 8 per cent of the carcinomas in this series were either *in situ* ($n = 6$) or intra-mucosal carcinomas ($n = 2$). The proportion of patients with multiple carcinomas was close to that expected (EKELUND & PIHL 1974). As in other series, the majority of the tumours were found in the sigmoid colon (de JONG et coll. 1972), as well as in the rectum (BERGE et coll. 1973).

Although DCE provides a good picture of the integrity of the colonic mucosa (SHAY & GERSHON-COHEN 1934, WELIN 1967, FORK 1980), the conventional barium examination would be sufficient for demonstrating carcinomas deforming the contour of the lumen (COOLEY et coll. 1960). Further, in patients with left-sided, stricturing tumours, air is not insufflated or, if so, with extreme caution to avoid or aggravate an acute obstruction. However, in our series, DCE was always applied in an effort to delineate the diseased segment and to reveal any additional lesion (MORETON & YATES 1949). No complications were observed.

Of the 127 polyps found in specimens from 31 patients with colorectal carcinomas, only 38 in 15 patients were disclosed by DCE. This may be explained by incomplete bowel evacuation in patients with large, symptomatic carcinomas. The patients were prepared according to an earlier described method (FORK et coll. 1982).

The relative number of coexisting polyps found in patients with carcinoma was slightly larger in the present series than in that reported on by BERGE et coll. (1973). Furthermore, we could also show a lower frequency of benign neoplastic epithelial polyps in the rectum than expected (BERGE et coll. 1973), i.e. a frequency more in accordance with that reported by CORREA et coll. (1972). On the other hand, this uneven distribution supports the hypothesis that the proba-

bility of an adenoma being malignant varies with its position in the large bowel (EKELUND 1974, MORSON 1974 b).

Our study has shown that the majority of the carcinomas were well to moderately differentiated. This observation is in good agreement with earlier reports in the literature (MOERTEL 1973). However, on surgical exploration, 24 of these 71 carcinomas exhibited metastases in the regional lymph nodes (Table 4), corresponding to stage Dukes' C (DUKES 1932). This observation stresses the relatively minor significance of differentiation on the prognosis (SAUNDERS & MacEVEN 1971). On the other hand, poorly differentiated carcinomas exhibited metastases in regional lymph nodes in 86 per cent (19 of 22) of the specimens (Table 4).

Seven patients had malignant lesions other than adenocarcinoma coli. These lesions were all detected at DCE, which suggested malignant growth in all but the patient with the polypoid carcinoid of the caecum. The index roentgenograms were reviewed and all the lesions could be retrospectively differentiated from cancer of the colon.

In patients with carcinoma overlooked at DCE (Table 6 a), the roentgenograms of 2 patients showed nothing abnormal. One of these patients, operated on for a rectosigmoid carcinoma before the index DCE, showed no signs of recurrence at the DCE or at the earlier proctoscopy 3 months before the recurrence was recognized. In the other patient the quality of the films was poor. On reviewing the roentgenograms, the missed carcinomas were barely visible and had been interpreted as retained faecal material.

Nine carcinomas were diagnosed as benign lesions (Tables 6 a and b). In 3 patients diverticulitis of the sigmoid colon precluded the accurate radiologic diagnosis, even confirmed upon reviewing the films. However, the neoplastic nature of 5 other lesions was recognized at DCE, though not their malignancy. This was mainly due to the relatively small size, 15 - 22 mm across, of 4. On the contrary, malignancy was suspected in 8 patients (Table 7) with large benign polyps. In all but one patient, these polyps were more than 20 mm across.

In summary, 14 of 17 neoplastic lesions were detected at DCE, although, not surprisingly, their true nature could not be revealed. Four of these carcinomas were microscopically "early", in situ or intramucosal, i.e. changes impossible

to depict radiographically. The radiological criteria for malignancy in the remaining microscopically "early" lesions were based on size and irregularity of the heads of these polyps.

During the follow-up period, no additional malignant lesion was detected. This means, then, that 2424 patients were assumed to be free of carcinoma of the colon at the time of the index DCE.

Until the last decade, the diagnostic accuracy of cancer of the colon was at many radiological departments between 82 and 90 per cent (CARMAN & FINEMAN 1923, CASE 1941, COOLEY et coll., FIGIEL et coll. 1963, SAUNDERS & MacEVEN 1971). However, with high-kV techniques, diluted barium suspension and compression spot films (GIANTURCO 1950), the accuracy rose to 99.8 per cent - the rectum excluded - in patients followed for 2 years only (FIGIEL et coll. 1963). Further, the tumour size was not accounted for, and polyps with microscopic malignancy were excluded. These polyps can be detected by DCE, provided the roentgenographic technique is adequately performed, for the present diagnostic limitation of colonic carcinoma has been shown to be 3 - 5 mm tumours (ANDREN et coll. 1955). It can be seen from the decision matrix (LUSTED 1971, GALEN & GAMBINO 1975) (Table 9) that the accuracy of DCE was 99.3 per cent. The predictive value of a positive DCE indicating malignancy in patients with cancer was slightly lower (92.1 per cent) than that of a negative DCE (99.6 per cent). This means that a single examination with the DCE method will, with 92.1 per cent probability, detect and predict any carcinoma and that it will miss only 0.4 per cent. These figures would be even better if the diagnostic concept of a neoplastic malignant lesion was broadened, i.e. if polyps detected at DCE and that are more than 20 mm across would have been accepted as clinically correct diagnoses of carcinoma, i.e. 6 false negatives (Table 6 a) and 2 false positives (Table 6 b) diagnoses. Moreover, 4 of these polyps were early carcinomas, i.e. exhibited no carcinomatous infiltration beyond the submucosa.

These figures of diagnostic capacity and reliability of the DCE method were obtained in a series with a high prevalence of colonic carcinoma, very close to that in the unselected population (National Bureau of Statistics, Swedish National Board of Health and Welfare).

Conclusions

With an adequate double-contrast examination, it is possible to detect 98 per cent of all colonic neoplastic lesions more than 15 mm across and in 90 per cent to predict the malignancy as well. The probability of a patient with a negative DCE being free of cancer was 99 per cent.

Summary

During a 9-month period, 2590 patients were referred for radiographic examination of the large bowel. All but 55 of these examinations were performed according to the double-contrast examination method (DCE).

The patients were followed prospectively from 40 to 48 months. Cancer of the colon or rectum was disclosed in 96 patients and other malignant lesions in 7 others. The carcinomas in 93 patients were diagnosed at the index DCE. During the follow-up period, carcinoma of the colon was revealed in another 10 patients, the malignancy having been obfuscated by diverticular changes in 3 patients and interpreted as polyps in 6 others.

The accuracy of the DCE was calculated at 99.3 per cent.

Acknowledgement

This project was supported by the Swedish Medical Research Council, Project No. B79-29X-4819-04.

References

- ANDRÉN L., FRIEBERG S. and WELIN S.: Roentgen diagnosis of small polyps in the colon and rectum. Acta Radiol 43 (1955), 201 - 208
- BERGE T., EKELUND G., MELLNER C., PIHL B. and WENCKERT A.: Carcinoma of the colon and rectum in a defined population. Acta Chir Scand Suppl 438 (1973)
- Cancer Incidences in Sweden, 1977. The Swedish Cancer Register. The National Board of Health and Welfare, Stockholm (1977)
- CARMAN R.D. and FINEMAN S.: Roentgenologic diagnosis of disease of colon. Radiology 4 (1923), 129 - 142
- CASE J.T.: Clinical approach to roentgen diagnosis of carcinoma of colon. Ill Med J 80 (1941), 145 - 152
- Causes of Death, 1976. National Bureau of Statistics, Stockholm (1976)
- COOLEY R.N., AGNEW C.H. and RIOS G.: Diagnostic accuracy of the barium enema study in carcinoma of the colon and rectum. AJR 84 (1960), 316 - 331
- CORREA P., DUQUE E., CUELLO C. and HAENSZEL W.: Polyps of the colon and rectum in Cali, Colombia. Int J Cancer 9 (1972), 86 - 96
- deJONG U.W., DAY N.E., MUIR C.S., BARCLAY T.H.C., BRAS G., FOSTER F. H., JUSSAWALLA D.J., KURIHARA M., LINDEN G., MARTINEZ I., PAYNEP M., PEDERSEN E., RINGERTZ N. and SHANMUGARATNAM T.: The distribution of cancer within the large bowel. Int J Cancer 10 (1972), 463 - 477
- DUKES C.E.: The classification of cancer of the rectum. J Path Bact 35 (1932), 323 - 332
- EKELUND G.: On colorectal polyps and carcinoma with special reference to their inter-relationship. Thesis, Lund (1974)
- EKELUND G.R. and PIHL B.: Multiple carcinomas of the colon and rectum. Cancer 33 (1974), 1630 - 1634
- FIGIEL L.S., FIGIEL S.J. and HENNESSEY A.: Carcinoma of the colon. Incidence of error in roentgen diagnosis. Amer J Gastroenterol 40 (1963), 487 - 503
- FISCHER A.W.: Über eine neue röntgenologische Untersuchungsmethode des Dickdarms: Kombination von Kontrasteinlauf und Luftaufblähung. Klin Wchnschr 2 (1923), 1595 - 1598
- FORK F-T: Resultatvergleich zwischen der Doppelkontrastuntersuchung des Dickdarms und der Koloskopie mit Biopsie. In: Welin/Welin: Die Doppelkontrastuntersuchung des Dickdarms. Georg Thieme Verlag, Stuttgart, N.Y. (1980)

- FORK F-T., EKBERG O., NILSSON G., RERUP C. and SKINHØJ A.: Colon cleansing regimens - a clinical study in 1200 patients. Gastrointest Radiol (1982) In press
- GALEN R.S. and GAMBINO S.R.: Beyond normality: The predictive value and efficiency of medical diagnoses. John Wiley & Sons, N.Y. (1975)
- GIANTURCO C.: High-voltage technic in the diagnosis of polypoid growth of the colon. Radiology 55 (1950), 27 - 29
- LINDSTRÖM C., ROSENGREN J.E. and EKBERG O.: Experimental colonic tumors in the rat. Acta Radiol 19 (1978), 799 - 816
- LUSTED L.B.: Decision-making studies in patient management. New Engl J Med 8 (1971), 416 - 424
- MILLER R.E.: Detection of colon carcinoma and the barium enema. Topics in Radiology. JAMA 230 (1974), 1195 - 1198
- MOERTEL C.G.: Cancer of the large bowel. In: Cancer Medicine, Eds: Frei E. and Holland J.F., Lea and Febiger, Philadelphia (1973)
- MORETON R.D. and YATES C.W.: Roentgenologic study of the colon. Value of the double contrast enema. Tex St J Med 45 (1949), 157 - 163
- MORSON B.C.: The polyp-cancer sequence in the large bowel. Proc R Soc Med 67 (1974 a), 451 - 457
- MORSON B.C.: Evolution of cancer of the colon and rectum. Cancer 34 (1974 b), 845 - 849
- SAUNDERS C.G. and MacEVEN D.W.: Delay in diagnosis of colonic cancer - a continuing challenge. Radiology 101 (1971), 207 - 208
- SHAY H. and GERSHON-COHEN J.: Diagnostic value of double contrast enema, with special reference to diagnosis of early neoplastic lesions of colon. Surg Gynecol Obstet 58 (1934), 52 - 57
- WEBER H.M.: The roentgenologic demonstration of polypoid lesions and polyposis of the large intestine. AJR 25 (1931), 577 - 589
- WEBER H.M.: Carcinoma of the colon: Its roentgenologic manifestation and differential diagnosis. Amer J Cancer 17 (1933), 321 - 341
- WELIN S.: Modern trends in diagnostic roentgenology of the colon. Brit J Radiol 31 (1958), 453 - 464
- WELIN S.: Results of the Malmö technique of colon examination. JAMA 199 (1967), 369 - 371
- WINAWER S.J., MELAMED M. and SHERLOCK P.: Potential of endoscopy, biopsy and cytology in the diagnosis and management of patients with cancer. Clin Gastroenterol 5 (1976), 575 - 595

Departments of Diagnostic Radiology^{1/} (Chairman: Professor Tord Olin, M.D.),
Pathology^{2/} (Chairman: Professor Nils Sternby, M.D.), and Surgery^{3/}
(Chairman: Professor Bengt Zederfeldt, M.D.), Malmö General Hospital,
University of Lund, Malmö, Sweden

THE DOUBLE-CONTRAST EXAMINATION IN
INFLAMMATORY LARGE BOWEL DISEASE
A prospective clinical, radiographic, and
pathologic study

F.T. FORK^{1/}, G. LINDSTRÖM^{2/} and G. EKELUND^{3/}

Summary

In a prospective clinical series of 2 371 consecutive patients referred for double-contrast examination of the large bowel, 154 had clinical and/or radiographic signs of inflammatory disease. The patients were followed up from May 1976 until May 1981. At the interpretation of the roentgenograms, the radiologist was unaware of clinical and laboratory findings. In 31 patients, organ specimens were studied histologically and in 101, other multiple endoscopic biopsies were available. Based on the clinical observations and the pathology reports, the accuracy of the DCE was calculated at 99 %; the predictive value of a positive DCE at 92, and that of a negative DCE at 99 %.

Introduction

The choice of radiographic procedures for investigating patients with chronic inflammatory bowel disease has been the subject of extensive debate (3, 4, 9, 13, 17, 18, 19, 24, 26, 27, 29, 33, 40, 42, 46, 47). The aetiology of the chronic non-specific disorders, i.e. ulcerative colitis (UC) and Crohn's disease of the colon (CDC), is still obscure (15, 38). Some clinical and experimental investigations suggest that the features of these two diseases are various manifestations of a single, fundamental disorder (11, 43). On the other hand, other research work indicates the heterogeneity of these diseases (16, 27, 37, 42), although the similarities in clinical and biological features are recognized. Because the biopsy specimens obtained by endoscopic procedures are tiny, even the skilled pathologist is not always able to make a differential diagnosis with certainty (32, 34, 44). However, it is important to differentiate between these diseases since the medical and surgical treatments differ (10, 14, 16, 21), and the role of the radiologists in evaluating patients with these disorders has been stressed (18, 22, 25, 26, 27, 47).

The purpose of this investigation was to assess the accuracy of the diagnostic results obtained at the double-contrast examination of the large bowel - henceforth referred to as DCE - with special attention to inflammatory lesions of the colon and rectum. For this reason, a large group of patients that had been

TABLE 1. Radiographic signs compatible with ulcerative colitis (UC) and Crohn's disease of the colon (CDC)

	UC	CDC
Ulcers	not sharply defined, superficial	sharply demarcated aphtoid or punched- -out
depth	superficial	superficial to trans- mural, fissures and fistula
distribution	continuous	scattered
symmetry	even, stippled appearance	asymmetrical, cobble- stone appearance
Mucosa	granular	normal between the ulcers solitary nodules
Lumen	evenly narrowed, loss of rectal folds	localized strictures, asymmetrically narrowed
Localization	predominantly left- sided including the rectum	predominantly right- sided
Terminal ileum	normal or dilated. The ileocaecal valve open	superficial to transmural changes, strictures



Fig. 1. Male, aged 30 years, afflicted with ulcerative colitis for 8 years. There is an extensive granularity of the mucosa and slight tubulation of the descending colon



Fig. 2. A. Male, aged 37 years, with aphthoid and punched-out ulcers in descending colon



Fig. 2. B. Six months later, skipped lesions are seen. In the transverse colon solitary nodules and transmural lesions are depicted. Note the normal mucosa in between

referred for radiographic examination of the large bowel were followed up prospectively.

Material and methods

A prospective study of 2 590 consecutive patients, electively referred for radiographic examination of the large bowel, was initiated in May 1976. Because of severe deterioration in the general condition, 55 debilitated patients were examined with the single barium enema procedure and were therefore excluded, as were 164 others in whom the bowel had not been properly prepared. This left 2 371 patients for the present study.

During a 9-month period, these patients were examined with DCE (6, 7, 17, 45, 46). They were then followed up carefully, and any clinical observation, endoscopic and histopathologic finding, until May 1980 was recorded. Patients in whom no histologic tissue specimen was available during this period were followed up until May 1981. The mean observation period was 44 months. All specimens were examined by one pathologist (C.L.). The results of the index DCE's (the first DCE's) were then compared with the results from the follow-up procedures in order to calculate the diagnostic efficacy of a single DCE report, in our study, the index one.

Unless otherwise stated, the patients were prepared for the DCE with a combination of low-residue foods, overhydration followed by oral administration of magnesium sulfate and anthraquinone derivatives (1, 5, 8, 35). When deemed necessary, a 2-litre tap-water enema was administered 30 to 60 minutes before the DCE (8).

In an attempt to estimate the diagnostic quality of the DCE procedure, every examination was classified according to an arbitrary system. Thus, the preparation of the bowel in each patient was scored numerically 1 to 3 (viz. 1, adequately cleansed; 2, small amount of mucus remaining; and 3, faecal material interfering with the diagnosis) and the technical quality of the films was scored in 4 groups (adequate, good, low, and not acceptable). Patients in the not acceptable group were excluded.



Fig. 3. Female, aged 45 years, with proctitis. At DCE slight granularity of the rectal mucosa is seen, the rectal folds preserved and normal mucosa in the sigmoid. Non-specific proctitis at DCE

All DCE's were interpreted routinely by 2 radiologists. During this study all the roentgenograms were, in addition, interpreted by a third roentgenologist (F.T.F.) who was uninformed as regards clinical and radiographic reports. If the latter's interpretation rendered a positive finding that had been missed, the clinician was informed in writing, and was thus obligated to initiate further investigations. The results from these follow-up studies later on formed the basis upon which the validity of the DCE was assessed. The differential diagnosis of non-specific colitis was considered unequivocal only in patients with pathology reports on major organ specimens and acceptably certain when based on composite clinical observations and histologic reports on biopsy specimens.

The radiographic diagnoses of UC and CDC were based on the conventional findings summarized in Table 1 (3, 4, 13, 17, 18, 40, 42, 47) (Figs. 1 and 2). In the present study, the term non-specific colitis is used to designate chronic non-specific colitic disorders - including indeterminate colitis - other than UC and CDC. The radiographic diagnosis of non-specific colitis was based on discrete granularity, shallow haustral folds, and slight irregularity of mucosal folds. These changes were often found in the distal parts of the large bowel, in one or two segments only (Fig. 3).

Results

Of the 2 371 patients, 154 had clinical symptoms ascribable to an inflammatory disease of the large bowel. The overall numerical scores regarding both bowel preparation and technical film quality of the index DCE are presented in Table 2. In 6 patients the technical quality of the roentgenograms was inferior (score 3). Upon reviewing the roentgenograms, it was obvious that the overall technical score in 3 of the 6 patients, by all rights, should have been 4 - faecal residue obfuscating the mucuous membrane - and these patients were therefore excluded afterwards. Thus, 151 patients remained, 68 men and 83 women (Fig. 4), mean age 35 years, range 10 to 80 years.

Radiographically, 44 patients had signs of UC. The age (median 32.5 years) and sex distribution are given in Fig. 5. The final clinical diagnosis was the

TABLE 2. The overall quality of the index DCE in patients with colitis (n = 154). Score 1: adequate, 2: acceptable, 3: lesions up to 5 mm cannot be excluded, 4: rejected. Figures represent number of patients

		SCORE			
		1	2	3	4
Patients with	Total				
	151	119	29	3	0
Ulcerative colitis	44	36	8	(1 ⁺)	
Crohn's disease of the colon or rectum	24	20	4	(1 ⁺)	
Non-specific colitis	66	52	14	(1 ⁺)	
Miscellaneous	17	11	3	3	

+ / patient excluded

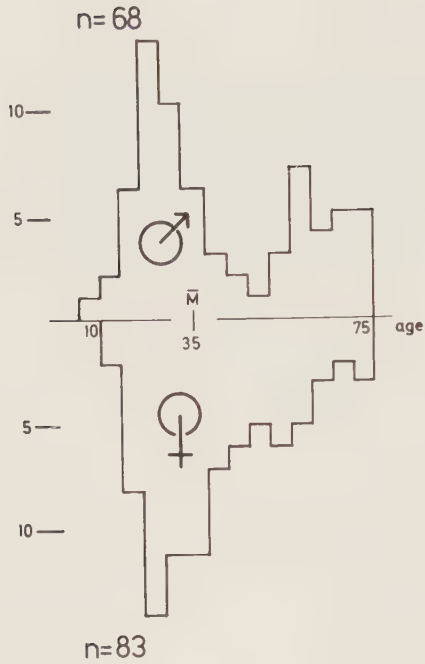
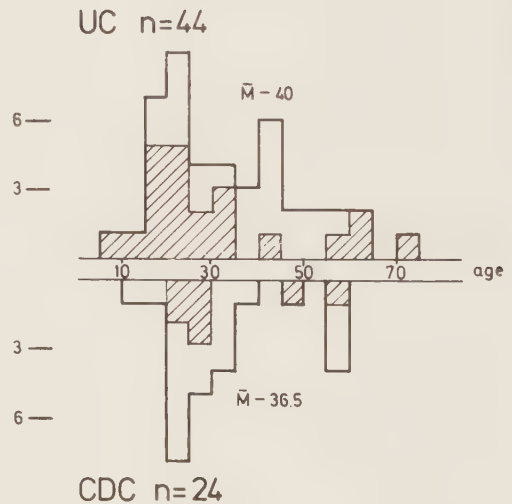


Fig. 4. Age and sex distribution of patients with colitis

Fig. 5. Sex and age distribution in patients with ulcerative colitis (UC) and Crohn's disease of the colon (CDC). Hatched areas denote number of males. Median age of patients with UC was 32.5 and with CDC 30 years



same in 37 patients, whereas 4 were considered to have non-specific colitis and 3 were in remission (Table 3).

Radiographically and clinically, respective 22 and 24 patients had signs attributable to CDC (Tables 2 and 4, Fig. 5). Two patients presented non-specific changes at DCE. One of these had ankylosing spondylitis. In one patient with histologically normal tissue specimens, total colonoscopy revealed signs of CDC. In 55 patients non-specific changes indicating inflammatory bowel disease other than UC and CDC were seen radiographically (Table 5). In 13 other patients, in whom the pathologist reported non-specific colitis, nothing abnormal was observed upon interpreting the roentgenograms. In 6 of the former ($n = 55$) patients (Table 5), the tissue specimens showed no sign of inflammation, although the rectoscopist reported proctitis in 2 of them, giving a total of 4 false positive DCE diagnoses.

Miscellaneous findings were revealed in tissue specimens from 8 patients: inflammatory changes due to irradiation in 6, solitary ulcer in one, and microscopically inflammatory changes of an indeterminate type in one. In 10 patients no tissue specimens had been obtained for histologic examination until March 1982: clinically, 2 patients had had UC for more than 6 years; one had been examined with DCE during an episode of frequent diarrhoea of unknown origin; one suffered from chronic constipation and was abusing senna alkaloids; and another, an alcoholic, was examined with DCE during a period of diarrhoea and was not further followed up (Fig. 6). The remaining 5 patients had clinically only vague bowel symptoms at referral.

Tissue specimen from one out of 27 patients with signs of non-specific colitis showed post-colitic changes. Another one of these patients suffered from Crohn's disease of the terminal ileum and ankylosing spondylitis of the lumbar spine (Fig. 7).

Tissue specimens from 16 out of 17 patients with miscellaneous radiographic diagnoses (Table 6) revealed acute inflammatory changes due to diverticulitis in 4, one of whom exhibited changes suggesting CDC as well. Colitic changes only involving the mucosa were seen in 5 patients with carcinoma of the colon, and changes due to irradiation, ischaemia, solitary ulcer syndrome, and colitis cystica profunda were observed in 5 other patients. Radiographically, 3 patients had signs of colitis cystica profunda and one of pneumatosis cystoides of the recto-sigmoid.

TABLE 3. Number of patients with inflammatory changes compatible with ulcerative colitis on index DCE

		ULCERATIVE COLITIS AT DCE		
		Clinical diagnoses		
		Ulcerative colitis	Non-specific colitis	Miscellaneous
Histopathologic diagnoses	Total			
	44	37	4	3
Ulcerative colitis	26	26		
Non-specific colitis	12	8	3	1
Normal	2			2
Not examined	4	3	1	

TABLE 4. Number of patients with colitic changes compatible with Crohn's disease on index DCE

		Crohn's colitis at DCE		
		2 segments or more of the colon	Caecal or anastomotic region	Regional ileitis
Histopathologic diagnoses	Total			
	22	17	4	1
CDC	13			
Non-specific colitis	1	1		
Probably CDC	2	2		
and CD of terminal ileum	3	2	1	
Normal	1	1 ⁺		
Not examined	2	2		

+ / colonoscopy shows signs of CDC

TABLE 5. Number of patients with non-specific colitis according to radiographic diagnoses or pathology reports

		Non-specific colitis at DCE (n = 55)		No colitis at DCE
		the rectum only	several segments	
Histopathologic diagnoses	Total			
	68	23	32	13
CDC	2			
Non-specific colitis	27	5	10	12
Mild	5	2	3	
Probably 1: UC	6	6		
2: CDC	4	2	2	
Miscellaneous	8	3	4	1
Normal	6	4	2	
Not examined	10	1	9	



FIG. 6. Male, aged 51 years. Non-specific changes in the descending colon in an alcoholic



Fig. 7. Male, 34 years of age. Clinically treated for UC. Radiographically, small bowel disease compatible with Crohn's disease. Ankylosing spondylitis. Advanced stricture in the right flexure, irregular narrowing in the mid-descending colon and numerous inflammatory polyps. The right hemicolon only slightly involved

TABLE 6. Patients with acute colitis and other synchronous lesions

		Roentgenographic diagnoses		
		Diverti- culitis	Carcinoma	Miscellaneous
Histopathologic diagnoses	Total			
	17	8	5	4
Diverticulitis	4	4		
Pericarcinomatous inflammation	7		5	2
Miscellaneous	5	3		2
Not examined	1	1		

Tissue specimens from 134 out of 151 patients were available (Table 7), whereas in 17 patients no tissue specimens, even until March 1982, were available. Radiographically, 4 of them had UC, 2 CDC, and 10 non-specific colitis, confined to the rectum in one. One patient in which diverticulitis was disclosed by the DCE was never operated on.

Radiographically, the diagnosis of non-specific colitis ($n = 55$) was based on the following: discrete granularity of the rectal mucosa ($n = 23$) with shallow folds of Houston ($n = 13$), shallow haustral folds in combination with lumen narrowing ($n = 22$), irregularity of the lumen in various sites of the large bowel in combination with faint mucosal changes and irregularity of mucosal folds on post-evacuation films ($n = 4$). Although vague, the radiographic changes in 45 patients closely resembled those observed in UC. One of these patients had profound changes in the colon that was not possible to classify (Fig. 7).

The diagnostic agreement according to type of inflammatory bowel disease between the radiographic examination of the large bowel and histopathologic examination of tissue specimens from the large bowel is evident from Table 8 A. The agreement was total in 69 patients, compatible according to persistent inflammation in another 27 patients, and totally incongruent in 22, in whom one diagnostic modality was judged as normal ($n = 13 + 9$). Assuming the pathology report as the ultimate answer as to the type of inflammatory bowel disease, the sensitivity of the DCE was calculated at 89.0 %, the specificity at 99.6 %, the predictive value of a positive DCE at 92.1 %, and that of a negative DCE at 99.4 % (Table 8 B).

During the follow-up period, no patient with a normal index DCE later revealed signs of chronic inflammatory bowel disease at follow-up DCE's.

Discussion

The aetiology of UC and CDC is enigmatic. Clinical and experimental investigations are guided by theories - on the one hand, assuming these diseases to lie at opposite ends of a single, basic pathogenetic process (2, 11, 28, 39, 43) and on the other, stating their differences (15, 20, 22, 31, 34, 36, 38, 41, 49). This

TABLE 7. Diagnostic procedures other than DCE. Figures denote number of patients from whom tissue specimens were obtained

		Number of biopsy procedures in patients with radiographically			
		UC	CDC	Non-specific colitis	Miscel- laneous findings
Tissue specimen obtained through	Total				
	204	61	40	83	20
Surgery	31	8	13	3	7
Rectoscopy	115	37	19	51	8
Colonoscopy	52	16	8	26	2
Post-mortem examination	6			3	3
Number of patients	134	40	20	58	16

TABLE 8. Type of inflammatory bowel disease as to the pathology report on tissue specimens available from 118 patients (those accounted for in Table 6 not included).

A. Figures denote patients with various radiographic diagnoses

		Roentgenographic diagnoses			
		UC	CDC	Non-specific colitis	No signs of colitis
Pathology reports	Total				
	118	40	20	45	13
UC	26	26			
CDC	15		15		
Non-specific colitis	60	12	6	30	12
Miscellaneous	8			7	1
No sign of colitis	9	2	1	6	

TABLE 8. B. The evaluation of the effect of DCE in
inflammatory bowel disease

D i a g n o s e s m a d e a t			
DCE	Histopathology		Total
	colitis	no colitis	
Colitis	105	9	114
No colitis	13	2208	2221
Total	118	2217	2335

Sensitivity of DCE: $105/118 = 0.890$

Specificity of DCE: $2208/2217 = 0.996$

Accuracy of DCE: $(105 + 2208)/2335 = 0.991$

The predictive value of a positive DCE: $105/114 = 0.921$

The predictive value of a negative DCE: $2208/2221 = 0.994$

insecurity is thus reflected in the difficulties for the radiologist (25) and pathologist to make a sharp distinction between these diseases in every patient. This is true even for about 10 % of total organ specimens (34). In addition, there is clinically no consistent, significant difference between patients with UC and those with CDC according to age of onset, sex ratio, or symptomatology, although rectal bleeding occurs in almost every patient with UC (16).

However, the two diseases have pathological differences: viz. in UC the continuous pattern of mucosal inflammation, oedema, shallow ulcerations, and healed granular mucosa; and in CDC, the persisting, relatively undisturbed mucosa between scattered, sharply defined ulcers, which range from small aphtoid ulcers to longitudinally and transmurally, deep fissures (22). Roentgenographically, it is also possible to demonstrate the asymmetrical, eccentric involvement, fistulas, and the characteristic cobblestone appearance seen in CDC; and inflammatory polyps, multiple and clustered, in UC (17, 22, 23, 48) (Table 1).

The diagnosis of chronic non-specific inflammatory bowel disease should be made only after the exclusion of specific disorders of the colon caused by infections, neoplastic lesions, ischaemic or radiation injuries, or other defined disorders (15, 16, 22). Clinically, it is important to differentiate UC from CDC, for the medical and surgical treatments differ (10, 14, 21).

Today, the DCE technique is generally accepted as the method of choice for exploring subtle mucosal changes (3, 13, 17, 18, 24, 42, 47). The aim of the present study was to assess the ability to diagnose inflammation of the large bowel and to differentiate between UC and CDC at the DCE in a prospective study of consecutive patients. To achieve as high diagnostic reliability as possible the patients were followed radiographically for at least 40 months and with any tissue specimens up to 60 months.

It has been reported that it is possible to discriminate patients with UC and CDC in every, or almost every, case at DCE (43, 46). However, the authors with this opinion (43, 46) reported on series of patients with colitis who were selected at the DCE or at sigmoidoscopy. The DCE results were then confirmed by the endoscopic appearance, i.e. by macroscopic signs responsible for both radiographic and endoscopic pictures. The differentiation was mainly based on the diagnosis of discontinuous disease in CDC and the demonstration of granular mucosa in UC, the latter sign never seen in CDC (4).

It is obvious from the present study, as well as from other reports (23, 32), that a patient with radiographically normal mucosa may have microscopical signs of inflammation at endoscopic biopsy. Further, endoscopic specimens from patients with clinically and radiographically diagnosed CDC will only occasionally exhibit granulomata. Therefore, the diagnosis of the true nature of an inflammatory bowel disease must be based on accumulated data from clinical observations and results from repeated radiographic, endoscopic, and histopathologic examinations (12, 23, 31, 36, 42, 44, 48). This also applies to patients with UC, because non-specific inflammation is the typical histologic picture at rectal biopsy (30, 31).

This prospective clinical DCE study emphasizes the necessity of complementary results in order to make a correct diagnosis of chronic inflammatory bowel disease. Thus, the diseases in 51 % of the patients (60 of 118) was classified as non-specific according to histopathologic reports of specimens, mainly biopsies from endoscopic procedures. In specimens from 9 other patients, no inflammatory changes were seen; and in 13 patients with histologic signs of inflammation, no such signs were seen radiographically. Clinically, the disease was classified as non-specific colitis in 44 % (67 of 154) and radiographically in 36 % (55 of 151). In these 55 patients the inflammatory signs were radiographically vague and confined to the distal loop of the large bowel, comprising one or two segments only, most often including the rectum. In the majority of these patients ($n = 45$), UC was the most probable disease disclosed at the DCE, an observation that accords with other reports (17). Moreover, in 26 of them, this assumption was supported by rectal biopsies, revealing non-specific changes at microscopy, which is representative for UC (30, 31).

A hitherto not reported interesting observation in our series was that no patient with a normal index DCE subsequently revealed changes of chronic inflammatory bowel disease at follow-up DCE. This indicates that a patient developing such a disorder has no previous abdominal symptoms leading to a DCE and/or that the diagnosis is, to a great extent, a roentgenographic one. The absence of any demonstrable change at DCE makes the existence of an inflammatory disease unlikely. This indicates, then, the employment of a routine radiographic method that is sensitive as regards disclosure of subtle mucosal changes in order to obtain an early diagnosis. And the DCE according to the "Malmö method" seems reasonably sensitive for this purpose, according to our study.

Conclusions

To achieve a definitive diagnosis of an inflammatory disease of the large bowel, a complete evaluation of the results from clinical observations, repeat roentgenograms, and histopathologic studies of specimens is necessary. Based on such complete observations made during a follow-up period, the DCE proved to be an accurate radiographic method, i.e. a positive DCE for colitis was correct in 92 % and a negative DCE in 99 % of the patients studied.

Acknowledgement

This investigation was supported by the Swedish Medical Research Council, Project No. B79-29X-4819-04.

References

1. Barnes, M.R.: How to get a clean colon - with less effort. Radiology 91 (1968), 948 - 949
2. Bartnik, W., R.G. Shorter: Inflammatory bowel disease: immunologic developments. Developments in Digestive Diseases. Vol. 3, Ed. J.E. Berk, Lea and Febiger, Philadelphia (1980)
3. Bartram, C.I., K. Walmsley: A radiological and pathological correlation of the mucosal changes in ulcerative colitis. Clin. Radiol. 29 (1978), 323 - 328
4. Brahme, F.: Granulomatous colitis: roentgenologic appearance and course of the lesions. AJR 99 (1967), 35 - 44
5. Brown, G.R.: A new approach to colon preparation for barium enema: preliminary report. Univ. Michigan Med. Bull. 27 (1961), 225 - 230
6. Fischer, A.W.: Über eine neue röntgenologische Untersuchungsmethode des Dickdarms: Kombination von Kontrasteinlauf und Luftaufblähung. Klin. Wchnschr. 2 (1923), 1595 - 1598
7. Fischer, A.W.: Über die Röntgenuntersuchung des Dickdarms mit Hilfe einer Kombination von Lufteinblasung und Kontrasteinlauf. Langenbecks Arch. Chir. 134 (1925), 209 - 269
8. Fork, F.-T., O. Ekberg, G. Nilsson, C. Rerup, A. Skinhøj: Colon cleansing regimens - a clinical study in 1200 patients. In press. Gastrointest. Radiol. (1982)
9. Gianturco, C.: The comparative value of various methods in the roentgenologic examination of the colon. Illinois Med. J. 71 (1937), 67 - 74
10. Glotzer, D.J., W. Silen: The surgical approach to the treatment of chronic ulcerative colitis and Crohn's disease. In: Inflammatory Bowel Disease, Ed: J.B. Kirsner and R.G. Shorter, Lea and Febiger, Philadelphia (1980)
11. Gorbach, S.L.: Intestinal microflora in inflammatory bowel disease - implications for etiology and therapy. In: Inflammatory Bowel Disease, Ed: J.B. Kirsner and R.G. Shorter, Lea and Febiger, Philadelphia (1980)
12. Hogan, W.J., G.T. Hensley, J.E. Geenen: Endoscopic evaluation of inflammatory bowel disease. Med. Clin. N. Am. 64 (1980), 1083 - 1102
13. Kelvin, F.M., T.A. Oddson, R.P. Rice, J.T. Garbutt, B.P. Bradenham: Double contrast barium enema in Crohn's disease and ulcerative colitis. AJR 131 (1978), 207 - 213

14. Kirsner, J.B., M.J. Goodman: The medical treatment of inflammatory bowel disease. In: Inflammatory Bowel Disease, Ed: J.B. Kirsner and R. G. Shorter, Lea and Febiger, Philadelphia (1980)
15. Kirsner, J.B., R.G. Shorter, Editors: Inflammatory Bowel Disease. 2nd edition, Lea and Febiger, Philadelphia (1980)
16. Kirsner, J.B., R.G. Shorter: Recent developments in "nonspecific" inflammatory bowel disease. New Engl. J. Med. 306 (1982), pp 775 - 785, 837 - 848
17. Laufer, I.: Air contrast study of the colon in inflammatory bowel disease. CRC Critical Reviews in Diagnostic Imaging 12 (1977), 421 - 447
18. Laufer, I., J. Hamilton: The radiological differentiation between ulcerative and granulomatous colitis by double contrast radiology. Am. J. Gastroenterol. 66 (1976), 259 - 269
19. Ledoux-Lebard, R., J. Garcia-Calderon: Les techniques d'examen de la muqueuse du gros intestine. J. Radiol. d'Electrol. 17 (1933), 429 - 466
20. Lennard-Jones, J.E.: Definition and diagnosis. Regional Enteritis. Skandia Intern. Symp. Ed: A. Engel and T.K.L. Larsson, Stockholm (1971)
21. Lindhagen, T.: Crohn's disease in a defined population. Results of a surgical treatment. Thesis, Malmö (1982)
22. Lockhart-Mummery, H.E., B.C. Morson: Crohn's disease (regional enteritis) of the large intestine and its distinction from ulcerative colitis. Gut 1 (1960), 87 - 105
23. Loose, H.W.C., C.B. Williams: Barium enema versus colonoscopy. Proc. roy. Soc. Med. 67 (1974), 1033 - 1036
24. Margulis, A.R., H.I. Goldberg: The current state of radiologic technique in the examination of the colon: a survey. Radiol. Clin. N. Am. 7 (1969), 27 - 42
25. Margulis, A.R., H.I. Goldberg, T.L. Lawson, C.K. Montgomery, O.N. Rambo, C.D. Noonan, J.R. Amberg: The overlapping spectrum of ulcerative and granulomatous colitis: a roentgenographic-pathologic study. AJR 113 (1971), 325 - 334
26. Marshak, R.H., A.E. Lindner: Granulomatous colitis. Seminars in Roentgenol. 3 (1968), 27 - 61
27. Marshak, R.H., A.E. Lindner: Radiologic diagnosis of chronic ulcerative colitis and Crohn's disease. In: Inflammatory Bowel Disease, Ed: J.B. Kirsner and R.G. Shorter, 2nd edition, Lea and Febiger, Philadelphia (1980)
28. McConnell, R.B.: Inflammatory bowel disease: newer views of genetic influence. Developments in Digestive Diseases. Ed: J.E. Berk, Lea and Febiger, Philadelphia (1980)

29. Miller, R.E., F.Brahme: The clarity of good technic. Am. J. Digest. Dis. 12 (1967), 418 - 420
30. Morson, B.C.: Pathology of ulcerative colitis. In: Inflammatory Bowel Disease. Ed: J.B. Kirsner and R.G. Shorter, Lea and Febiger, Philadelphia (1980)
31. Morson, B.C., I.M.P. Dawson: Gastrointestinal Pathology. 2nd edition. Blackwell Scientific Publications, Oxford, London, Edinburgh, Melbourne (1979)
32. Myren, J., A. Serck-Hansen, L. Solberg: Routine and blind histological diagnoses on colonoscopic biopsies compared to clinical-colonoscopy observations in patients without and with colitis. Scand. J. Gastroenterol. 11 (1976), 135 - 140
33. Pantone, A.M., L. Berlin: Air-contrast examination of the colon: an entity of the past. Am. J. Digest. Dis. 12 (1967), 110 - 112
34. Price, A.B., B.C. Morson: Inflammatory bowel disease. The surgical pathology of Crohn's disease and ulcerative colitis. Human Pathology 6 (1975), 7 - 24
35. Rosengren, J.E., T. Åberg: Cleansing of the colon without enemas. Der Radiologe 15 (1975), 421 - 426
36. Roth, J.L.A.: Diagnosis and differential diagnosis of chronic ulcerative colitis and Crohn's colitis. In: Inflammatory Bowel Disease. Ed: J.B. Kirsner and R.G. Shorter, Lea and Febiger, Philadelphia (1980)
37. Sachar, D.B., M.O. Auslander, J.S. Walfish: Aetiological theories of inflammatory bowel disease. Clin. Gastroenterol. 9 (1980), 231 - 257
38. Schachter, H., J.B. Kirsner: Crohn's Disease of the Gastrointestinal Tract. John Wiley, New York (1980)
39. Shorter, R.G., K.A. Huizenga, R.J. Spencer: A working hypothesis for the etiology and pathogenesis of nonspecific inflammatory bowel disease. Am. J. Digest. Dis. 17 (1972), 1024 - 1032
40. Simpkins, K.C., G.W. Stevenson: The modified Malmö double-contrast barium enema in colitis: an assessment of its accuracy in reflecting sigmoidoscopic findings. Brit. J. Radiol. 45 (1972), 486 - 492
41. Taylor, K.B.: Ulcerative colitis and Crohn's disease of the colon: Symptoms, signs and laboratory aspects. In: Inflammatory Bowel Disease, Ed: J.B. Kirsner and R. G. Shorter, Lea and Febiger, Philadelphia (1980)
42. Thoeni, R.F., A.R. Margulis: Radiology in inflammatory disease of the colon: an area of increased interest for the modern clinician. Invest. Radiol. 15 (1980), 281 - 292

43. Watson, D.W., W. Bartnik, R.G. Shorter: Lymphocyte function and chronic inflammatory bowel disease. In: Inflammatory Bowel Disease, Ed: J. B. Kirsner and R.G. Shorter, Lea and Febiger, Philadelphia (1980)
44. Way, J.D.: Endoscopy in inflammatory bowel disease. Clinics in Gastroenterol. 9 (1980), 279 - 296
45. Weber, H.M.: The roentgenologic demonstration of polypoid lesions and polyposis of the large intestine. AJR 25 (1931), 577 - 589
46. Welin, S.: Modern trends in diagnostic roentgenology of the colon. Brit. J. Radiol. 31 (1958), 453 - 464
47. Welin, S., F. Brahme: The double contrast method in ulcerative colitis. Acta Radiol. 55 (1961), 257 - 271
48. Whitehead, R.: Pathology of Crohn's disease. In: Inflammatory Bowel Disease. Ed: J.B. Kirsner and R.G. Shorter, Lea and Febiger, Philadelphia (1980)



